

## **Chapter 12**

### **Powerplant Fire Penetration Test**

#### **12.1 Scope**

- 12.1.1 This test method is intended to determine the capability of components and constructions to control the passage of fire or its effects in powerplant (engine) compartments and, thereby, to prevent additional hazard to the aircraft.
- 12.1.2 This test is used to show compliance with FARs 25.867, 25.865, 25.1191, and 25.1193.

#### **12.2 Definitions**

##### **12.2.1 Firewall**

A firewall is a structure designed to prevent a hazardous quantity of air, fluid, or flame from exiting a fire zone in which a fire has erupted and causing hazard to the aircraft. Firewalls must be fireproof.

##### **12.2.2 Fireproof**

Per FAR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) “in designated fire zones means the ability of materials or parts to withstand the heat from a severe fire of extended duration at least as well as steel in dimensions appropriate for their purpose.”

- 12.2.2.1 Materials or parts are demonstrated to be fireproof by meeting requirements of this test for a flame exposure of 15 minutes.

##### **12.2.3 Fire Resistant**

Per FAR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) “with respect to fluid carrying lines, fluid system parts, wiring, air ducts, fittings, and powerplant controls means the capacity to perform the intended functions under the heat and other conditions likely to occur when there is a fire at the place concerned.”

- 12.2.3.1 Materials or parts are demonstrated to be fire resistant by meeting the requirements of this test for a flame exposure of 5 minutes.

##### **12.2.4 Heat Flux Density**

The rate of thermal energy transferred per unit area, expressed here in units of Btu/ft<sup>2</sup>-sec or W/cm<sup>2</sup>.

#### **12.3 Apparatus**

##### **12.3.1 Test Burner**

The burner will be a modified gun-type oil burner, such as Part Model DPL 3400, Stewart Warner HPR-250 or FR 600, Lennox OB-32, or Carlin 200 CRD. The burner will be calibrated to provide a minimum average flame temperature of 2,000°F (1,093°C) and a minimum heat transfer rate of 4,500 Btu/hr to the Btu heat transfer device described in chapter 11, section 11.3.3.2, or 9.3 Btu/ft<sup>2</sup>-sec (10.6 W/cm<sup>2</sup>) as measured by a calorimeter described in section 11.3.3.1.

###### **12.3.1.1 Burner Extension**

A stainless steel funnel extension fabricated in accordance with figure 11-1 will be used. The funnel will have an oblong exit 6 inches (152 mm) high by 11 inches (279 mm) wide. The funnel will be installed on the burner with the air tube shown in figure 11-2.

###### **12.3.1.2 Burner Fuel**

SAE No. 2 diesel, kerosene, or equivalent will be used for burner fuel.

### 12.3.2 Thermocouples

A thermocouple rake containing at least five ANSI 22-gauge Chromel-Alumel (Type K) thermocouples sheathed in 1/16 inch (1.6 mm) stainless steel or inconel tubes or equivalent will be provided. The thermocouples will be aligned in a row,  $1.0 \pm 0.1$  inch ( $25 \pm 2$  mm) apart.

### 12.3.3 Heating Rate Measuring Devices

One of the following devices will be used to measure the heating rate of the flame.

#### 12.3.3.1 Btu Heat Transfer Device

A Btu heat transfer device described in Chapter 11, "Power Plant Hose Assemblies Test," figures 11-5 to 11-10, in this handbook may be used.

#### 12.3.3.2 Calorimeter

A calorimeter capable of measuring heat flux densities up to 15 Btu/ft-sec (17 W/cm) may be used. A Hy-Cal model 1300A total heat flux density calorimeter available from Hy-Cal Engineering, Santa Fe Springs, California, or equivalent with water cooling has been found suitable.

### 12.3.4 Test Stand

A test stand will be provided to maintain the position of the thermocouple rake, calorimeter, or Btu heat transfer device, and test specimen. The test stand will include a provision for either moving the burner out of the test position or moving the test specimen into/out of test position. The test stand will also include a provision for positioning the thermocouple rake or burner extension parallel to the burner face with the thermocouple junctions on the diameter or major axis of the burner extension. A suitable test setup is shown in figure 12-1.

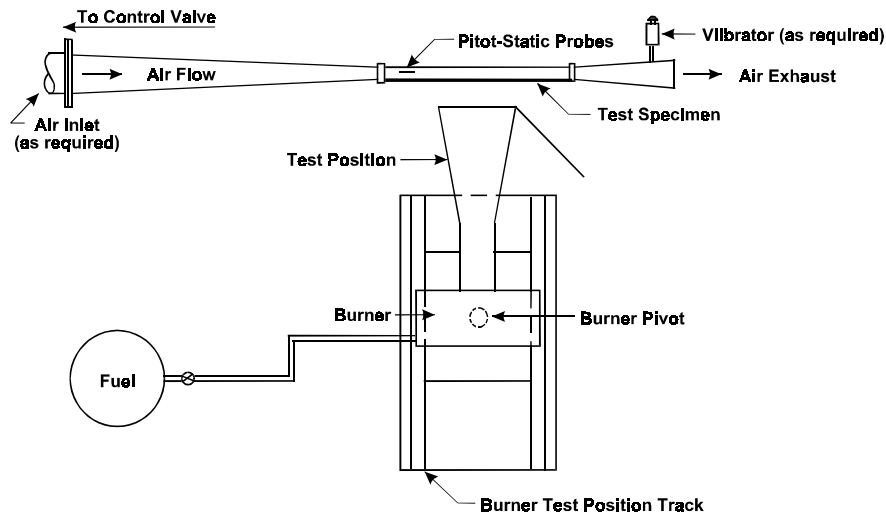


Figure 12-1. Firewall Penetration Test Setup—Top View

### 12.3.5 Timer

A stopwatch or other device, calibrated and graduated to the nearest 1 second, will be used to measure the time of application of the burner flame.

## 12.4 Test Specimens

### 12.4.1 Specimen Selection

Test specimens will be actual or simulated aircraft hardware, including all combustible materials that are applied to the actual structure in use. Heat flow paths and heat sinks will be as in the production configuration being certified.

### 12.4.2 Specimen Size

In general, specimen size will be 24 by 24 inches (610 by 610 mm). Larger specimens will be used if required to accommodate a critical design feature of the component. Smaller specimens 10 by 10 inches (254 by 254 mm) may be used if all design features are included and the specimen is representative of the intended use. For a smaller specimen, the backside of the specimen will be protected from exposure to the flame.

## 12.5 Conditioning

### 12.5.1 Specimen Conditioning

Specimens containing nonmetallic components will be preconditioned if required to simulate the aircraft environment.

## 12.6 Calibration

12.6.1 Place the thermocouple rake on the test stand such that the rake will be above the centerline of the burner or burner extension exit plane when the burner is in calibration position. Connect the thermocouples to a suitable recorder.

12.6.2 Light the burner, allow at least a 5-minute warmup, and move the burner into calibration (see section 12.3.4 for position).

12.6.3 Begin monitoring the temperatures indicated by the thermocouples after 5 minutes. Make adjustments as necessary to either the fuel flow or the airflow to the burner in order to achieve a minimum average thermocouple reading of 2,000°F (1,093°C).

12.6.4 Turn the burner off or move it out of calibration position and remove the thermocouple rake.

12.6.5 Replace the thermocouple rake with the heat flux density measuring device. Follow section 12.6.5.1 if using a water-cooled calorimeter for measuring heat flux density. Follow section 12.6.5.2 if using a Btu heat transfer device for this purpose.

12.6.5.1 If using the water-cooled calorimeter described in section 12.3.3.2, place the calorimeter at the same distance as the thermocouple rake centered over the burner exit.

12.6.5.1.1 Light the burner, allowing at least a 2-minute warmup, and move the burner into the calibration position.

12.6.5.1.2 Measure the heat flux density continuously or at intervals no greater than 10 seconds. If the heat flux density is not at least 9.3 Btu/ft-sec (10.6 W/cm) over a 1-minute period, readjust the burner to achieve the proper heat flux density. If burner adjustments are necessary, remove the heat flux density measuring device and repeat sections 12.6.1 through 12.6.5.1.2.

12.6.5.2 If using the Btu heat transfer device described in section 12.3.3.2, ensure the external surface of the copper tubing on the Btu heat transfer device is clean prior to measuring heat flux. Use fine steel wool to clean the copper tubing. Inspect the tubing bore and remove any corrosion and/or scale accumulation before each test. A .45-caliber pistol

cleaning brush, or equivalent, with an extension has been found suitable for this purpose.

12.6.5.2.1 The calibration setup is shown in figure 11-4. Provide a 5-foot (1.5-m) constant head of water above the heat transfer device and a 2-foot (0.61-m) drop to the end of the tailpipe for adjustment of the water flow rate. Use a 1-gallon (3.8-L) measuring container (a container and a weighing scale are also acceptable). Supply water at a temperature of 50° to 70°F (10° to 21°C). Adjust the water flow rate to 500 lb/hr (227 kg/hr) or 1 gal/min (3.8 L/min).

12.6.5.2.2 Start the water flowing through the Btu heat transfer device. Center the heat transfer tube in the flame at the same location that the specimen will be placed for testing. Allow at least a 2-minute warmup period to stabilize flame conditions before temperature measurements from the thermometers are recorded.

12.6.5.2.3 After the warmup period, record the inlet and outlet temperatures every 30 seconds for a 3-minute period. Determine the rate of Btu increase of the water as follows:

$$\begin{aligned}\text{Heat transfer} &= 146 \times (T_o - T_i) \text{ watts (for Celsius)} \\ &= 500 \times (T_o - T_i) \text{ Btu/hr (for Fahrenheit)}\end{aligned}$$

where:  $T_o$  = temperature (°C or °F) at outlet

$T_i$  = temperature (°C or °F) at inlet

12.6.5.2.4 The heat transfer rate output, as determined by the equation shown in section 12.6.5.2.3, will be a minimum of 4,500 Btu/hr (1,314 W). If the heat output from the burner is not above the minimum, make adjustments to the burner and repeat sections 12.6.1 through 12.6.5.2.3.

## 12.7 Procedure

In general, tests will be conducted at ambient conditions. However, special airflow, pressure, vibration, etc., conditions may be required to simulate the actual aircraft operating environment. Load-carrying specimens will be tested with limit loads applied during the test.

12.7.1 Light the burner and allow at least a 2-minute warmup.

12.7.2 Place the test specimen in test position at the same distance from the burner as the thermocouple rake and calorimeter were placed during calibration.

12.7.3 Start the timer when the test specimen is properly positioned with respect to the burner. The critical or representative area of the test specimen will be aligned with the center of the burner.

12.7.4 Terminate the test by moving the burner or test specimen out of the test position after 15 minutes, as required for fireproof materials, or after 5 minutes, as required for fire-resistant materials.

12.7.5 Note the condition of both faces of the test specimen.

12.7.6 Without making adjustments to the burner flame, repeat the temperature measurements described in sections 12.6.1 through 12.6.3. If the average temperature has decreased by more than 150°F (66°C), readjust the burner and repeat the test with a new specimen.

## 12.8 Report

12.8.1 Fully identify the construction being tested and its use.

12.8.2 Describe the test apparatus and burner. Include the average flame temperature and heat flux density (or heat transfer rate) data for pretest calibration and the average temperature for posttest calibration.

- 12.8.3 Report the time the specimen is exposed to flame and whether the material or part is fireproof or fire resistant.
- 12.8.4 Describe the test specimen before and after testing.

## 12.9 Requirements

- 12.9.1 No flame penetration will occur for the duration of the test.
- 12.9.2 Burning on the backside of the specimen is not acceptable. Significant burning on the side of flame impingement will be investigated to determine if a potential increase in hazard exists. Minor flashing on either side of the specimen is acceptable.

## Chapter 12 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

12.1.1 Advisory Circular AC20-135, "Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria," February 6, 1990.

12.3.1 An SAE AS401B Propane Burner is also acceptable, provided the temperature profile and heat flux density conform to the requirements specified in this test method.

12.3.2 Thermocouples can be either grounded or ungrounded, depending on the type of data system used to monitor thermocouple output. One condition may generate more interference with instrumentation than the other.

12.6.1 If using one of the conversion oil burners described in section 1.1 for this test, the distance used to position the rake, heat flux measuring device, and test specimen will be 4 inches (101.6 mm) from the burner cone exit. If the burner used is an SAE AS401B Propane Burner, the distance used to position the thermocouple rake, etc., may be as close as 2 inches (50.8 mm) from the burner face exit in order to achieve the temperature and heat flux density specified in this test procedure.

12.6.2 If using an SAE AS401B Propane Burner, the flame is not turned off during calibration or test setup. Most test facilities using this burner have provisions for moving the burner in and out of test position. If using a conversion oil burner, most facilities turn the burner on and off to change specimens and calibration equipment. If the burner is turned off at any time, it will be warmed up for a 2-minute period before testing or taking calibration measurements.

12.6.5.1 Operating the calorimeter without water running through it will permanently damage the calorimeter.

## **Chapter 13**

### **Test for Electrical Connectors Used in Firewalls**

#### **13.1 Scope**

- 13.1.1 This test method is intended for use in determining the resistance of high-temperature electrical connectors used in fire zones to damage due to flame and vibration according to requirements of FARs 23.1192, 25.1191, 27.1191, 29.1192, 25.863, 25.865, 25.867, 25.1201, and 25.1203.
- 13.1.2 This test is used to evaluate the capability of wired, electrical, firewall connectors to prevent flame from passing to the protected side of the firewall. This test provides a means to evaluate the connectors' ability to sustain a minimum current of 1A for a limited period of time.
- 13.1.3 It is suggested that each connector type be tested in three sizes: 22-19, 14-7, and 12-3. Each connector size will be tested separately.

#### **13.2 Definitions**

##### **13.2.1 Firewall**

A firewall is a structure designed to prevent a hazardous quantity of air, fluid, or flame from exiting a designated fire zone in which a fire may erupt and causing additional hazard to the aircraft.

##### **13.2.2 Firewall Connector**

A firewall connector is an electrical connector designed for installation in the firewall.

#### **13.3 Apparatus**

##### **13.3.1 Simulated Firewall**

A piece of steel 10 by 10 by 0.063 inch (254 by 254 by 1.6 mm) thick to simulate a firewall will be provided for each of the three connector sizes. A hole will be drilled in the center of each piece appropriate to the respective connector size. If the simulated steel firewall does not adequately represent the actual application, a test of the proposed configuration may be required.

##### **13.3.2 Burner/Torch**

A burner/torch modified to produce and maintain a minimum flame temperature of 2,000°F (1,093°C) will be provided.

###### **13.3.2.1 Burner Fuel**

Propane gas fuel of 99 percent minimum purity will be used with a gas flow rate equivalent to 33,000 to 37,000 Btu/hr.

##### **13.3.3 Power Supply (Electrical, AC)**

A center-tapped transformer will be provided that is capable of producing between 200V and 260V (AC) at 400 Hz or 60 Hz and delivering a current of at least 2A.

##### **13.3.4 Power Supply (Electrical, DC)**

A power source will be provided that is capable of producing 28V (DC) and a current between 5A and 150A.

##### **13.3.5 Current Indicator**

A multirange ammeter will be provided that is capable of measuring DC currents between 5A and 150A with an accuracy of 1 percent of full scale.

#### 13.3.6 Vibration Source

A means will be provided to vibrate the test fixture vertically at 33 Hz with a total excursion of 0.14 inch (3.6 mm).

#### 13.3.7 Gas Flowmeter

A gas flowmeter will be provided to measure the fuel flow to the burner/torch.

#### 13.3.8 Temperature Measuring and Recording Equipment

A temperature sensing system will be provided that includes a thermocouple and a stripchart recorder to monitor the flame temperature.

##### 13.3.8.1 Thermocouple

An ANSI 22-gauge Chromel-Alumel (Type K) thermocouple sheathed to a 1/16-inch (1.6-mm) stainless steel or inconel tube shall be provided.

#### 13.3.9 High-Temperature Tape

High-temperature tape, 19 to 25 mm wide, will be provided in sufficient length to wrap over the connector and wire bundles (see section 13.4.2.1).

#### 13.3.10 Test Fixture

A test fixture and setup such as is shown in figure 13-1, including a cable clamp to stabilize the wire bundle connector interface during the test, will be provided.

#### 13.3.11 Timer

A stopwatch or other device, calibrated and graduated to the nearest 1 second, will be used to measure the time of application of the burner flame.

### 13.4 Test Specimens

#### 13.4.1 Specimen Number

Prepare at least three specimens for each connector shell size to be tested.

#### 13.4.2 Specimen Preparation

Clean all oil, grease, dirt, and other foreign material from the specimens.

13.4.2.1 Wrap the plug and receptacle wire bundle with high-temperature tape over the area to be located under the cable clamp that is used to stabilize the wire bundle connector interface during flame/vibration application. This area is a distance of  $7.9 \pm 0.2$  inches ( $200 \pm 5$  mm) from the connector backshell. See figures 13-2 and 13-3 for details.

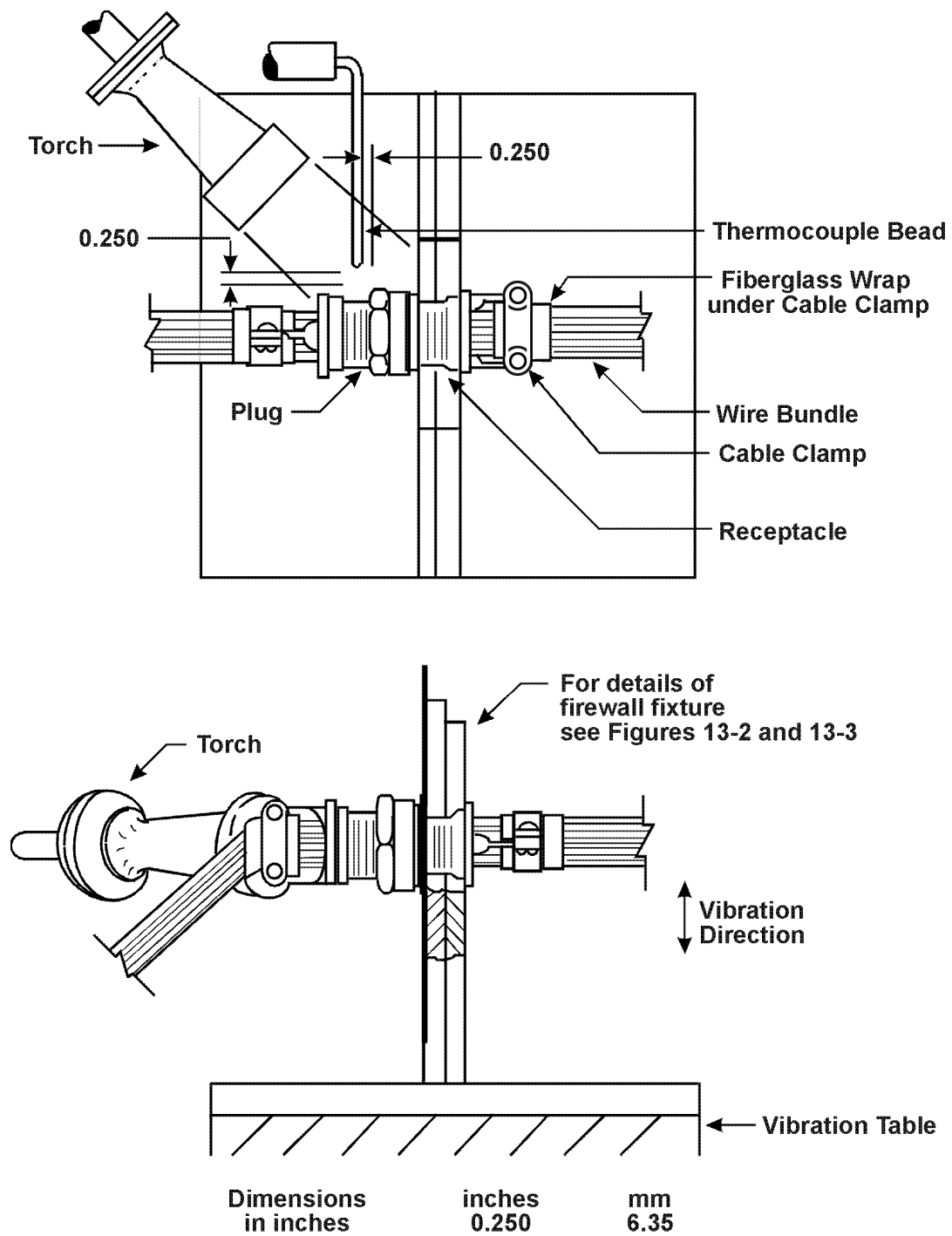


Figure 13-1. Firewall Connector Test Setup

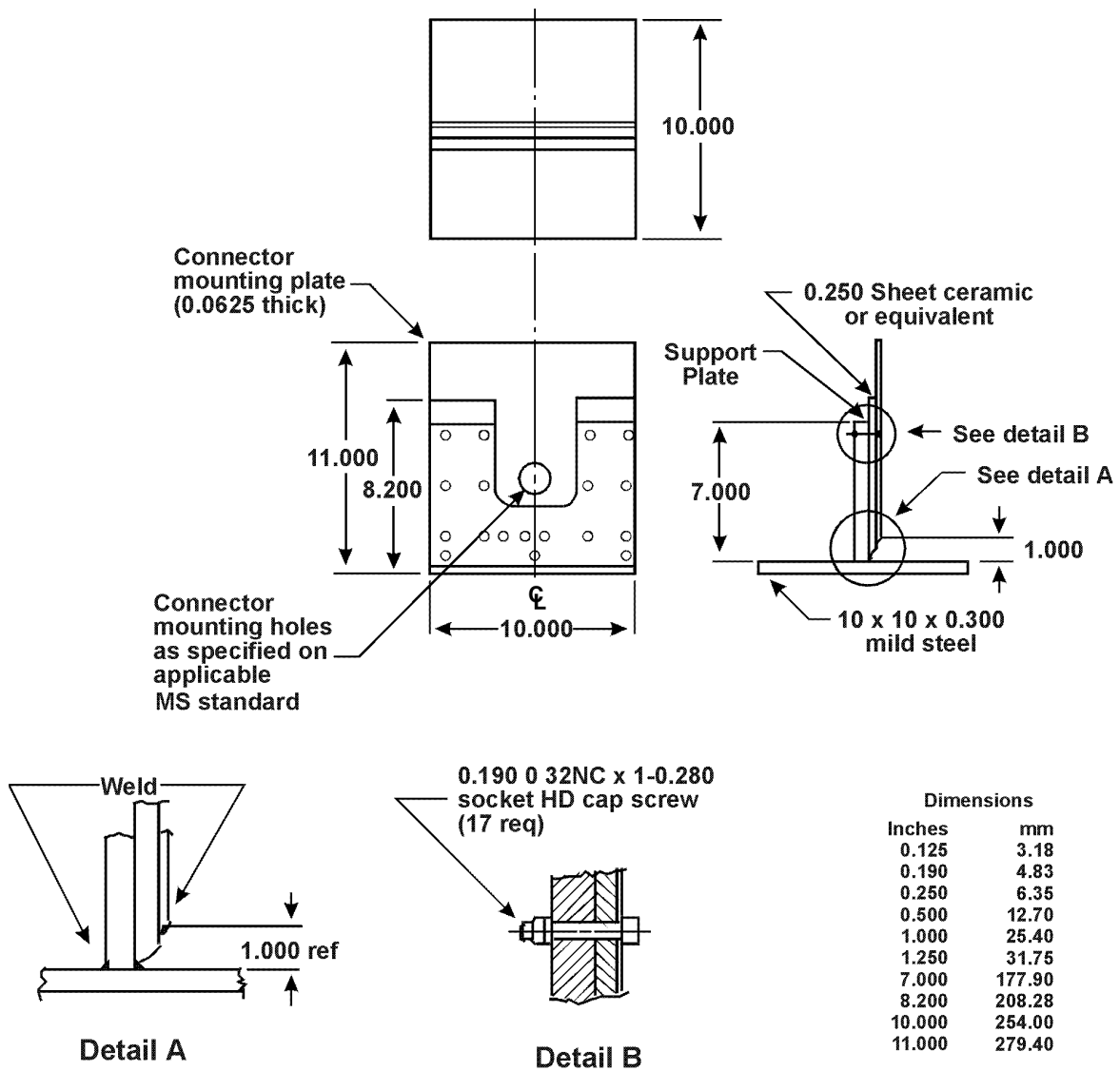
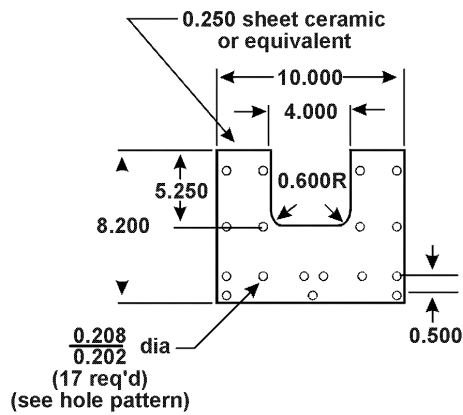
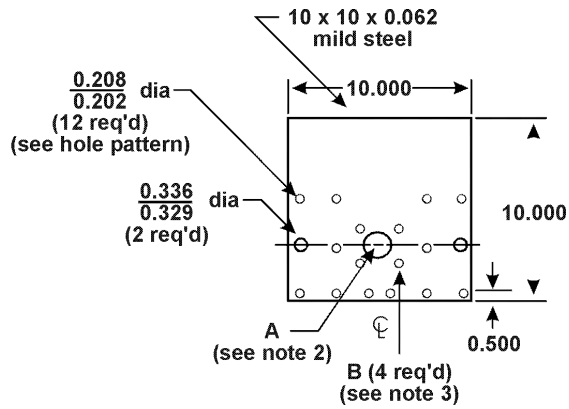


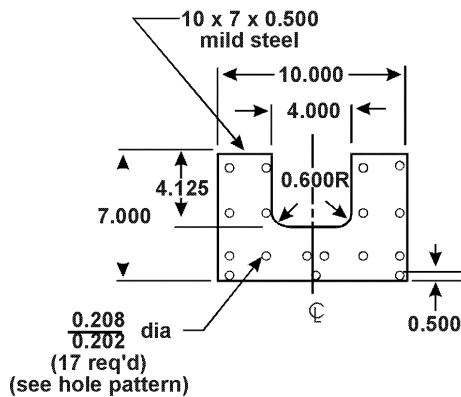
Figure 13-2. Firewall Connector Fixture Assembly



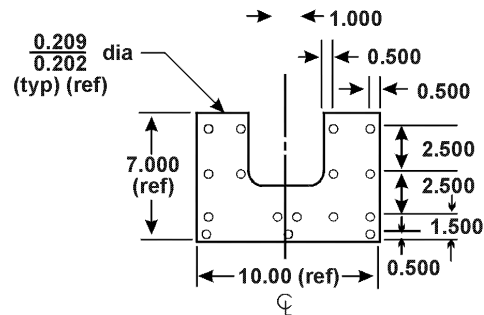
Sheet Ceramic



Connector Mounting Plate



Support Plate



Hole Pattern

Notes:

1. Dimensions are in inches. Unless otherwise specified, dimensions symmetrical about centerline.
2. A hole shall provide suitable clearance for the applicable connector.
3. B connector mounting holes shall be as specified on the applicable MS standard.

Inches	mm
0.125	3.18
0.190	4.83
0.250	6.35
0.500	12.70
1.000	25.40
1.250	31.75
7.000	177.80
8.200	208.28
10.000	254.00
11.000	279.40

Figure 13-3. Firewall Connector Fixture Details

- 13.4.2.2 Connect the individual wires through the connector such that the circuit will be closed. Ensure that the connector shell is grounded during the test.

## 13.5 Procedure

### 13.5.1 Test Setup

Mount the simulated firewall on the vibration equipment table. Mount the connector that has been wired, mated, and prepared as described in sections 13.4.2.1 and 13.4.2.2 in the center of the simulated firewall test fixture.

- 13.5.1.1 Support the wire bundle, using clamps to a stationary structure at a distance of  $7.9 \pm 0.2$  inches ( $200 \pm 5$  mm) from the connector backshell on each side of the connector to protect from vibration.

- 13.5.1.2 Ensure that the connector shell is well grounded prior to starting the test.
- 13.5.1.3 Use a circuit for the test designed so that by closing one switch or relay (designated as Switch 2), the connector contacts are connected in series and the direct current potential is applied and, by closing another switch or relay (designated Switch 1), the alternating current potential is applied between even and odd numbered contacts, as shown in figure 13-4.

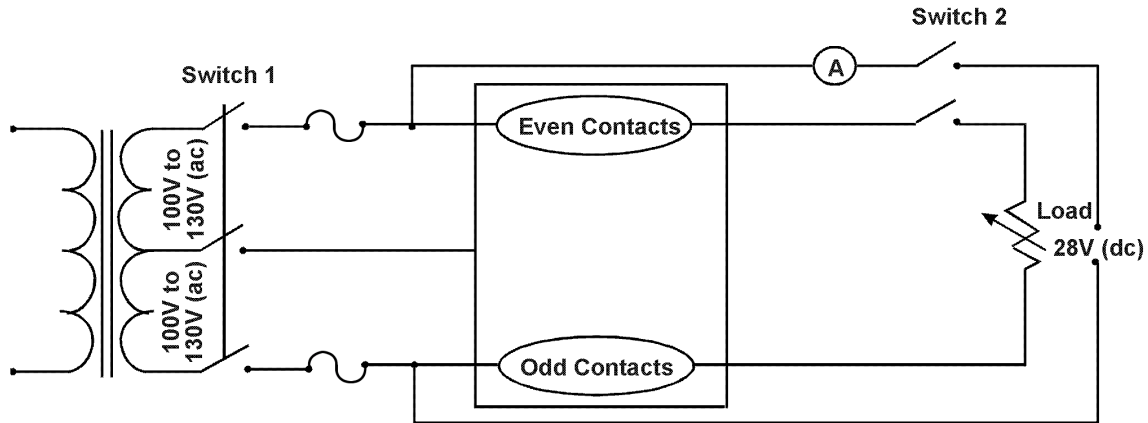


Figure 13-4. Connector Electrical Integrity Connection Diagram

#### 13.5.2 Burner Adjustment

Ignite the burner/torch and adjust the flow of gas and air to obtain a nonoxidizing and nonreducing flame with a flame temperature of  $2,000^{\circ} \pm 50^{\circ}\text{F}$  ( $1,093^{\circ} \pm 28^{\circ}\text{C}$ ).

#### 13.5.3 Test Procedure

- 13.5.3.1 Light the burner and stabilize the flame at a minimum temperature of  $2,000^{\circ}\text{F}$  ( $1,093^{\circ}\text{C}$ ) for 5 minutes prior to starting the test.
- 13.5.3.2 Turn on the vibration source and connect the circuit, as described in section 13.5.1.3.
- 13.5.3.3 Simultaneously start the timer and direct the flame at the plug side of the connector test specimen, as shown in figure 13-2, at a distance such that the thermocouple monitoring the temperature is within 0.26 inch (6.5 mm) of the connector. Monitor the temperature of the flame continuously.
- 13.5.3.3.1 For the first 5 minutes of the test, connect the contacts in series and load with their rated DC current for the appropriate size contact as determined by table 13-1. Start the current flow by closing Switch 2. Monitor the current continuously using the ammeter to determine whether or not the connector circuit retains its conductance.

Table 13-1. Firewall Connector Test Current

Contact Size	Test Current (DC)
22	5
20	7.5
16	13
12	23
8	46
4	80
0	150

- 13.5.3.4 At the end of 5 minutes, the difference in potential of the even and odd numbered contacts will be 200V to 260V (AC) and the difference in potential between the shell and any contact will be 100V to 130V (AC). Remove the DC source and break the series connection by closing Switch 1. Immediately after Switch 1 is closed, apply the AC potential by opening Switch 2. Do not allow the circuit to draw a current greater than 2A. At the end of 1 minute, shut off the current. Observe and record any indication of an increase in current that would show a contact-contact or a contact-shell short circuit.
- 13.5.3.5 Continue the flame exposure of the connector until a total time of 20 minutes has elapsed and monitor whether any flame appears on the protected side of the firewall.

## 13.6 Report

### 13.6.1 Material Identification

Identify the material being tested.

### 13.6.2 Flame Penetration

Report whether any flame was detected on the protected side of the firewall during the test.

### 13.6.3 Conductivity

Report the minimum current that occurred during the application of electrical power.

### 13.6.4 Circuit Integrity

Report any evidence of a contact-contact or a contact-shell short circuit.

## 13.7 Requirements

### 13.7.1 Flame Penetration

There will be no flame detected on the protected side of the firewall barrier at any time during the 20-minute test.

### 13.7.2 Conductivity

The current through the connector during the application of electrical power will not be less than 1A.

### 13.7.3 Circuit Integrity

There shall be no evidence of any contact-contact or contact-shell short circuit.

### 13.7.4 Backside Ignition

There shall be no ignition on the backside of the wire bundle.

## **Chapter 13 Supplement**

This supplement contains advisory material pertinent to referenced paragraphs.

13.3.2 An SAE AS401 Propane Burner or equivalent has been found acceptable.

13.3.5 Choose the appropriate range of the ammeter to measure the test current. The appropriate range will show the current to be in the middle one-third of the scale.

13.3.9 Untreated fiberglass tape has been found satisfactory.

## **Chapter 14**

### **Test for Electrical Wire Used in Designated Fire Zones**

#### **14.1 Scope**

- 14.1.1 This test method is intended for use in determining the resistance of high-temperature electrical wire used in designated fire zones to damage due to flame and vibration according to the requirements of FARs 25.863, 25.865, 25.867, 25.1201, 25.1203, and 25.1359.
- 14.1.2 This test method generally follows MIL-W-25038E. The method is used predominantly in the United States and by most wire and cable manufacturers. ISO/DIS 2685.2 is a similar test procedure and is used by Aerospatiale in France and by the Civil Aviation Authority in Great Britain.

#### **14.2 Definitions**

##### **14.2.1 Ignition Time**

Ignition time is the length of time the burner flame is applied to the specimen. In this test, the ignition time is 5 minutes.

##### **14.2.2 Wire**

A single insulated electrical conductor.

##### **14.2.3 Designated Fire Zone**

A region of the aircraft, such as engine and auxiliary power unit compartments, designated to require fire detection and extinguishing equipment and, as appropriate, the use of materials that are fire resistant or fireproof.

##### **14.2.4 Fire Resistant**

Per FAR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) “with respect to fluid carrying lines, fluid system parts, wiring, air ducts, fittings, and powerplant controls means the capacity to perform the intended functions under the heat and other conditions likely to occur when there is a fire at the place concerned.”

- 14.2.4.1 Electrical wire is demonstrated to be fire resistant by meeting the requirements of this 5-minute test.

##### **14.2.5 Firewall**

A structure designed to prevent a hazardous quantity of air, fluid, or flame from exiting a designated fire zone in which a fire has erupted and causing additional hazard to the aircraft.

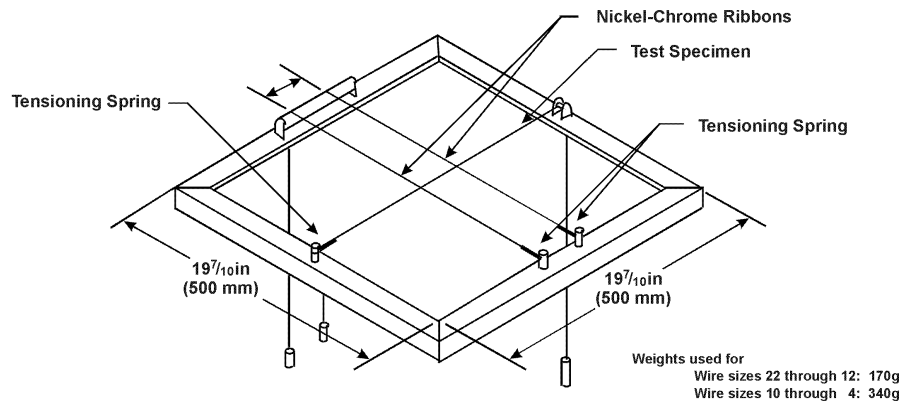
##### **14.2.6 Fire Zone Wire**

A wire installed in a designated fire zone.

#### **14.3 Apparatus**

##### **14.3.1 Test Fixture**

A test fixture, such as shown in figure 14-1, will be provided. The fixture will include a provision for mounting above the test burner.



*Figure 14-1. Firezone Electrical Wire Test Setup*

#### 14.3.2 Test Burner

A test burner, such as shown in figure 14-2, will be provided. The burner will include provisions for introducing air premixed with the gas fuel and for introducing secondary air into the burner flamelets.

##### 14.3.2.1 Burner Fuel

Propane gas of 99 percent purity will be used for the burner fuel.

##### 14.3.2.2 Plumbing for Gas Supply

The necessary gas connections, tubing, pressure regulators, and gauges will be provided.

#### 14.3.3 Vibration Source

A means will be provided to vibrate the test fixture vertically at 33 Hz with a total excursion of 0.14 inch (3.5 mm).

#### 14.3.4 Thermocouple

A 22-gauge ANSI (Type K) Chromel-Alumel thermocouple or equivalent, as shown in figure 14-3, will be provided to measure the temperature of the burner flame. In addition, a device to continually monitor the thermocouple output within an accuracy of 5 percent will be provided.

#### 14.3.5 Ammeter

An ammeter will be provided that measures a current of at least 2A within an accuracy of 5 percent.

#### 14.3.6 Ohmmeter

An ohmmeter will be provided to measure resistance within an accuracy of 5 percent of full scale.

#### 14.3.7 Power Source

A power supply will be provided that will deliver 2A at 115V AC, 400 Hz or 60 Hz.

#### 14.3.8 Nickel-Chrome Ribbons

Two nickel-chrome ribbons that are 0.010 by 0.059 by 23.6 inches (0.25 by 1.5 by 600 mm) will be provided (see figure 14-1).

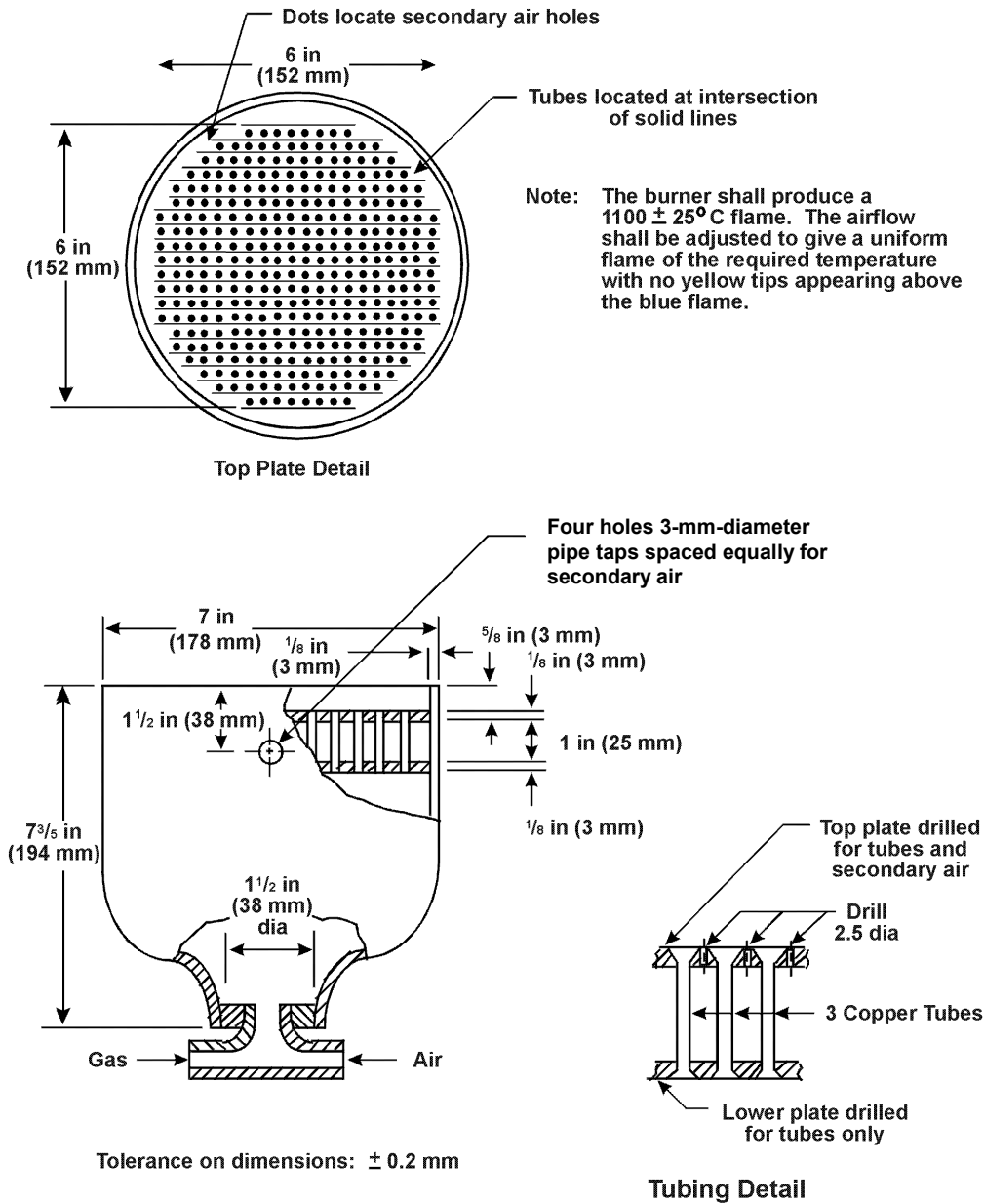


Figure 14-2. Burner Details

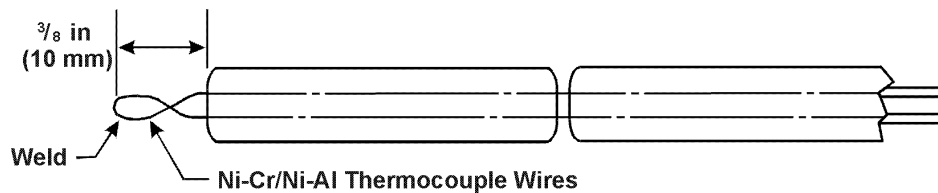


Figure 14-3. Thermocouple Details

#### 14.3.9 Weights

Weights are required to tension the wire over the test fixture. Suggested weights are 12 ounces (340 g) for wire sizes 4 through 10 and 6 ounces (170 g) for wire sizes 12 through 22.

#### 14.3.10 Reagents and Materials

The following materials found in the fire zone of intended use may be necessary to condition the specimens prior to the test:

14.3.10.1 Aviation fuel such as JP-4 or JP-5 or per MIL-G-5572

14.3.10.2 Lubricating oil per MIL-L-6082, Grade 1100

14.3.10.3 Hydraulic fuel per MIL-H-5606

#### 14.3.11 Timer

A stopwatch or other device, calibrated and graduated to 1 second, will be used to measure the time of application of the burner flame.

### 14.4 Test Specimens

#### 14.4.1 Specimen Length

Specimens will be 24 inches (610 mm) in length.

#### 14.4.2 Specimen Number

Twelve test specimens will be prepared unless otherwise specified. Three specimens will be tested for each condition: no conditioning, conditioning in aviation fuel, conditioning in hydraulic fuel, and conditioning in lubricating oil (see section 14.5.1).

### 14.5 Conditioning/Preparation of Test Specimens

#### 14.5.1 Test Conditions

Each wire type will be tested without being exposed to any contaminating fluid and after being exposed to each of the fluids described in section 14.3.10. Three test specimens will be used for each of the test conditions.

14.5.1.1 Immerse three test specimens in each test fluid for the times and temperatures shown in table 14-1. Wipe the test specimens with a clean cloth after removing them from the fluids.

*Table 14-1. Specimen Immersion Information*

Specimen No.	Test Fluid	Immersion	
		Time (hr)	Temp (°C)
1	Mil-G-5572 (grade 100/130)	24	23
	JP-5	24	23
	JP-4	24	23
2	50% JP-4 and 50% MIL-L-6082	24	23
3	MIOL-L-6082	24	121
4	Skydrol 50084/L04 (aero)	24	23
5	Ethylene Glycol (aero)	24	121

14.5.1.2 Locate the point on the wire specimen that will be located directly above the center of the burner when the wire specimen is placed on the test stand. Mark a 7-inch (178-mm) -long section with this point in its center by placing a wire band around the specimen

3 1/2 inches (89 mm) on each side of this point. In addition, place an outer wire band around the test specimen 4 inches (102 mm) outside each of these two bands.

14.5.2 Store each set of test specimens in a separate airtight container until the time of the test.

## 14.6 Calibration

14.6.1 Position the thermocouple as shown in figure 14-3, 1 inch (25 mm) above the center of the burner top plate, as shown in figure 14-4.

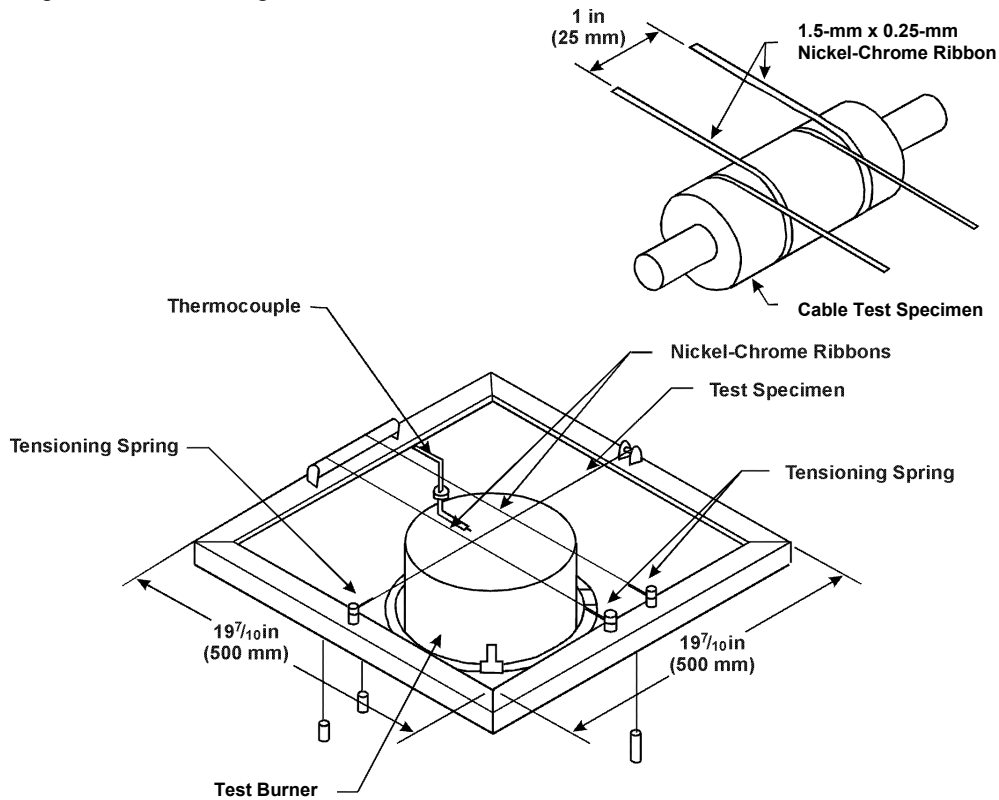


Figure 14-4. Fire Zone Electrical Wire Test Setup—Top View

14.6.2 Ignite the burner and adjust the fuel, air, and secondary air to the burner to obtain a nonoxidizing, nonreducing flame with no yellow tips at a temperature of  $2,000^{\circ} \pm 50^{\circ}\text{F}$  ( $1,093^{\circ} \pm 28^{\circ}\text{C}$ ). Stabilize the flame for 5 minutes.

14.6.3 Turn off the burner after the flame is properly adjusted.

## 14.7 Procedure

### 14.7.1 Test Setup

Position the test specimen 1 inch (25 mm) above the burner top plate. Place the center 7-inch (178-mm) section of the specimen above the center of the burner (see figure 14-4).

14.7.1.1 Position the two nickel-chrome ribbons at a distance of 1 inch (25 mm) apart, as measured at the center 7-inch (178-mm) section of the ribbons and perpendicular to the test specimen. Clamp one end of each of the nickel-chrome ribbons to the test fixture. Wrap the nickel-chrome ribbons around the wire and tension with weights. Lock the wires at the pulley or clamp them to the test fixture. See figure 14-4 for details.

14.7.1.2 Connect the conductor and the nickel-chrome ribbons as shown in figure 14-5.

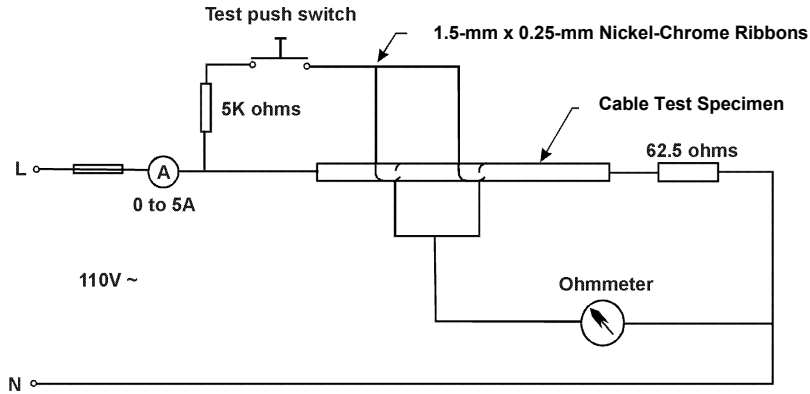


Figure 14-5. Electrical Connections

14.7.1.3 Insert a shorting bar between the conductor and the nickel-chrome ribbons. Adjust the ohmmeter to zero in this position.

14.7.1.4 Start the vibration using a frequency of 33 Hz and a vertical amplitude of 0.014 inch (3.5 mm).

#### 14.7.2 Test Procedure

Start the vibration using a frequency of 33 Hz and a vertical amplitude of 0.014 inch (3.5 mm).

14.7.2.1 Simultaneously start the timer and apply the ignited burner to the specimen.

14.7.2.2 Monitor the flame temperature for the duration of the test. Adjust the secondary air continually as necessary to keep the flame and the temperature within the limits specified in section 14.6.2.

14.7.2.3 Monitor and record the insulation resistance shown by the ohmmeter for the duration of the test, starting at 7.5 seconds after the test begins. In addition, record the lowest resistance shown by the ohmmeter during the test.

14.7.2.4 Monitor and record the current in the conductor during the test with the ammeter.

14.7.2.5 Turn off the burner and the vibration, in that order, at the end of the 5-minute test period.

## 14.8 Report

#### 14.8.1 Material Identification

Fully describe the wire type being tested. Include manufacturer, manufacturer's product designation, manufacturer's part number, specification callout (if applicable), insulation type, conductor size, and material.

#### 14.8.2 Insulation Integrity

Report whether the insulation flakes or falls off the conductor.

#### 14.8.3 Insulation Resistance

Report the insulation resistance at 7.5 seconds into the test and the lowest resistance occurring during the test and the time of its occurrence.

#### 14.8.4 Flame Travel

Report whether flame travel on the wire extended beyond the outer marking bands.

#### 14.8.5 Conductor Amperage

Report the amperage carried through the conductor throughout the duration of the test.

### 14.9 Requirements

The following acceptance criteria must be met by each specimen tested.

#### 14.9.1 Insulation Integrity

The insulation will not flake excessively or fall off the conductor.

#### 14.9.2 Insulation Resistance

The minimum insulation resistance of the wire under test will be at least 10,000 ohms for the duration of the test.

#### 14.9.3 Flame Travel

The flame travel on the insulation will not exceed beyond the outer bands.

#### 14.9.4 Conductor Amperage

The conductor will be able to carry a current of at least 2A throughout the duration of the test.

## Chapter 14 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

14.3.2 See SAE AS-8028 for burner details.

14.3.10 The reagents needed for conditioning vary, depending on the airframe manufacturer.

14.4.1 ISO/DIS 2685.2 calls out test specimens that are 30 inches (750 mm) long. MIL-W-25083 calls out test specimens that are 24 inches (600 mm) long. The difference in length does not affect test results.

14.5.1 All current industry specifications require only one specimen for each fluid. However, testing three specimens for each fluid will provide a greater degree of confidence in results.

14.5.1.2 The wire band consists of one turn of AWG 30 or smaller wire.

14.7.2.5 Monitoring the conductor has been added in addition to the requirements found in MIL-W-25038. This is done in both the firewall connector test procedure MIL-STD-1344 Test Method and the ISO/DIS 2685.2 test procedure for wire. The integrity of the conductor would be as important as the integrity of the insulation if the wire were faced with an in-flight fire situation.

## **Chapter 15**

### **Two Gallon per Hour Oil Burner Certification Testing for Repaired Cargo Compartment Liners**

#### **15.1 Scope**

- 15.1.1 This test method gives certification test procedures for repair of damaged cargo liners which would include, but not be limited to, ceiling and sidewall liners, pressurized cylinder cover liners, fabric liners, and compartment separation liners. Repairs should not be made to areas of the cargo liner that are designed for blowout in case of decompression.
- 15.1.2 Repairs generally consist of patches of fiberglass reinforced materials bonded to the cargo liners to cover rips, tears, and punctures that result from wear, abuse, and accidents. The patches are usually coated with an intumescent-type material to prevent separation during heat exposure.
- 15.1.3 Because of the large array of damage types that can occur to cargo liners, the following test procedures are aimed at ensuring that all types of repairs can safely contain a cargo compartment fire.
- 15.1.4 Soft or neoprene-coated fabric liners, typically used as partition separators, must also be included in this category and should follow the identical testing procedures as the conventional liners when repairs are made.

#### **15.2 Test Specimens**

The sample cargo liner used in the test specimens must be identical to the in-service liner in both material type and thickness, since certain thicknesses of liner may react quite differently than others. Thicker liners release significantly more amounts of heat than do thinner liners. Thinner (conventional type) liners contain less reinforcement, thereby providing less structural support to which the repair unit can adhere. If a patch is intended for use on a variety of liner thicknesses, tests should be run for each thickness. As an alternative, tests may be run on the minimum and maximum thicknesses of liners that the repair patch will be used on in service to alleviate the testing of all thicknesses within this range. Similarly, if there are several variants of a particular liner resin structure (i.e., fiberglass reinforcement with several slightly different phenolic resins), it is only necessary to test the generic construction (fiberglass/phenolic) and not every single resin type.

##### **15.2.1 Liner Repair Burnthrough Resistance Specimen**

###### **15.2.1.1 Specimen Configuration**

A flat sheet of material, identical to that used in the construction of the repair unit (patch), must be tested for resistance to burnthrough in the ceiling position of the cargo liner test apparatus.

###### **15.2.1.2 Specimen Size**

The burnthrough resistance sample shall measure 16 by 24 inches and contain the necessary mounting holes, as shown in figure 15-1.

###### **15.2.1.3 Specimen Number**

A minimum of three samples for each type of repair unit material shall be prepared.

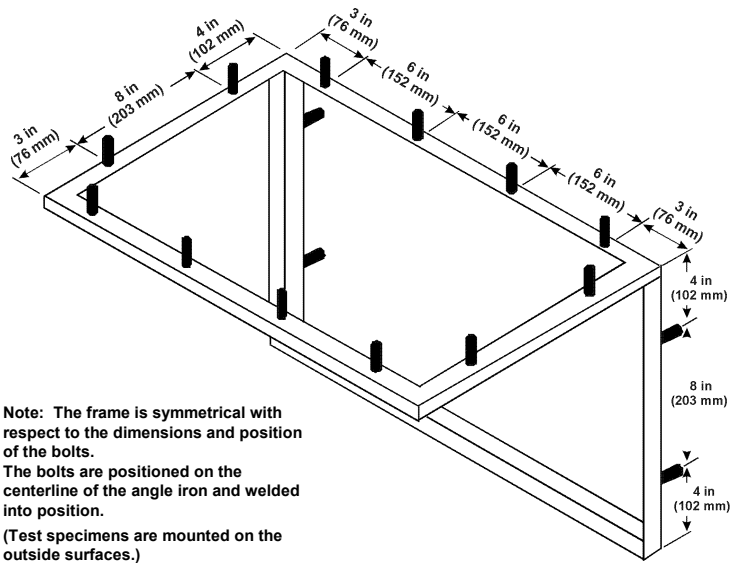


Figure 15-1. Cargo Liner Test Specimen Frame

## 15.2.2 Liner Repair Adhesion Specimen

### 15.2.2.1 Specimen Configuration

The repair patch must be placed over the standard damage area in the sample liner. The damage area must measure 5 by 5 inches with a width of 1 inch, in the form of an L-shape, and positioned according to figure 15-2. The placement of the repair patch in this location has been shown to be the most severe.

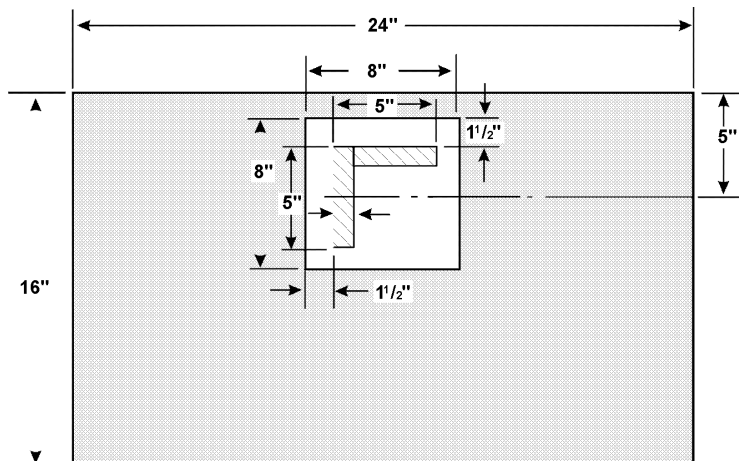


Figure 15-2. Eight- by Eight-Inch Patch Over Standard Damage

### 15.2.2.2 Specimen Size

The repair patch must measure 8 by 8 inches and be positioned over top of the damage area, according to figure 15-2. The liner sample must measure the standard 16 by 24 inches including the necessary mounting holes (see figure 15-1).

### 15.2.2.3 Specimen Number

A minimum of three samples must be prepared for each type of repair unit material.

### 15.2.3 Liner Repair Shingling Specimen

#### 15.2.3.1 Specimen Configuration

Two 4- by 4-inch patches must be overlapped by 1 inch and placed over the standard damage area in the sample liner. The damage area must measure 1 by 5 inches and be positioned as shown in figure 15.3.

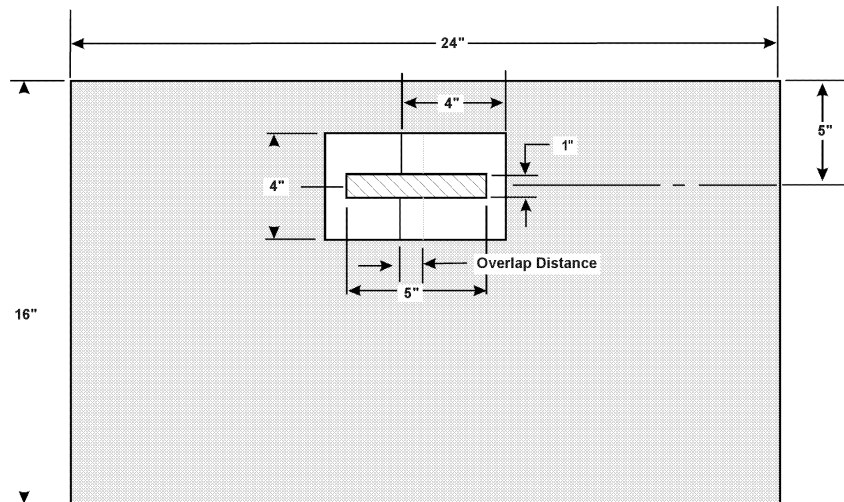


Figure 15-3. Overlapped Patches for Shingling Test

#### 15.2.3.2 Specimen Size

Patches must measure 4 by 4 inches, and the sample liner must measure the standard 16 by 24 inches including mounting holes (see figure 15-1).

#### 15.2.3.3 Specimen Number

A minimum of three samples must be prepared for each type of repair patch.

## 15.3 Specimen Conditioning

15.3.1 The specimens shall be conditioned at  $70^{\circ} \pm 5^{\circ}\text{F}$  ( $21^{\circ} \pm 2^{\circ}\text{C}$ ) and  $55\% \pm 5\%$  relative humidity for a minimum of 24 hours prior to testing.

## 15.4 Procedure

Reference FAA technical documents DOT/FAA/CT-TN88/33, DOT/FAA/CT-TN89/17, and DOT/FAA/AR-TN95/83 for a description of related test results and the development of this test procedure.

#### 15.4.1 Burnthrough Resistance Test

The material that comprises the primary fire barrier of the repair patch must be tested in a flat sheet, 16 by 24 inches, in the ceiling position of the cargo liner test apparatus. The sidewall area of the apparatus should be blocked off with either Kaowool ceramic fiber board or Marinite block. Follow procedures in chapter 8, section 8.8 to conduct the burnthrough test.

#### 15.4.2 Adhesion Test

In addition to the burnthrough resistance test, the repair patch must also display the ability to remain adhered to the liner specimen under the same conditions. The patched liner will be tested in the ceiling position of the test apparatus with the sidewall area blocked off with Kaowool board or

Marinite. Follow the procedures outlined in chapter 8, section 8.8 paying close attention to the positioning of the repair patch over the standard damage area.

#### 15.4.3 Shingling Test

The repair patch must also display its ability to shingle, since most repairs are long tears, and a single patch is not sufficient to cover the entire damage area. The overlapped patches, when placed on the liner specimen material, must be tested in the ceiling position of the cargo liner apparatus with the sidewall area blocked off with either Kaowool board or Marinite block. Follow the procedures in chapter 8, section 8.8 to conduct the test.

### 15.5 Report

A record of burner test apparatus calibration should be provided for each of the above repair patch tests.

#### 15.5.1 Burnthrough Resistance Test of Repair Patch

- 15.5.1.1 Report a complete description of the material(s) being tested including manufacturer, type of liner, thickness of liner, etc.
- 15.5.1.2 Record any observations regarding the behavior of the test specimen during flame exposure such as delamination, resin ignition, smoke, etc., and the time of occurrence of each event.
- 15.5.1.3 Report the time of occurrence of flame penetration, if applicable, for each of the specimens tested.
- 15.5.1.4 If flame penetration does not occur, report the maximum backside temperature and the time of occurrence.

#### 15.5.2 Adhesion Test of Repair Patch

- 15.5.2.1 Report a complete description of the material(s) being tested including manufacturer; type of repair patch; type of intumescent coating, if used; type and thickness of liner specimen; type of attachment (rivets); etc.
- 15.5.2.2 Record any observations regarding the behavior of the test specimen during flame exposure such as delamination, separation of repair patch from sample liner, lifting or curling of repair patch edges, resin ignition, smoke, etc., and the time of occurrence of each event.
- 15.5.2.3 Report the time of occurrence of either flame penetration or repair patch separation, if applicable, for each of the specimens tested.

#### 15.5.3 Shingling Test of Repair Patch

- 15.5.3.1 Report a complete description of the material(s) being tested including manufacturer; type of repair patch; type of intumescent coating, if used; type and thickness of liner; type of attachment (rivets); etc.
- 15.5.3.2 Record any observations regarding the behavior of the test specimen during flame exposure such as delamination; separation of the two patches, allowing passage of flames; lifting or curling of repair patch edges; resin ignition; smoke; etc., and the time of occurrence of each event.
- 15.5.3.3 Report the time of occurrence of either flame passage or patch separation, if applicable, for each of the specimens tested.

## 15.6 Requirements

### 15.6.1 Liner Repair Burnthrough Resistance

- 15.6.1.1 None of the three specimens tested shall burn through at any time during the 5-minute test.
- 15.6.1.2 The backface temperature must not exceed 400°F at any time for any of the test specimens when measured at 4 inches above the liner sample, over the center point of the burner cone.

### 15.6.2 Liner Repair Adhesion

- 15.6.2.1 The repair unit must remain totally adhered to the liner specimen during the entire 5-minute test. Minor curling or lifting of the repair patch that occurs near the edges is acceptable, provided no flames penetrate the standard damage area.

### 15.6.3 Liner Repair Shingling

- 15.6.3.1 Repair units (4- by 4-inch patches) must remain totally adhered to the liner specimen during the entire 5-minute test. Minor curling or lifting of the repair patch that occurs near the edges is acceptable, provided the shingled area remains attached along the entire seam and no flames penetrate the standard damage area.

## **Chapter 16. Reserved**

## **Chapter 17. Reserved**

## Chapter 18

### Recommended Procedure for the 4-Ply Horizontal Flammability Test For Aircraft Blankets

#### 18.1 Scope

This test method is intended for use in determining the resistance of blankets to flame when tested in the horizontal position and exposed to the Bunsen burner for 12 seconds.

#### 18.2 Definitions

##### 18.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the specimen. It is 12 seconds for this test.

##### 18.2.2 Flame Time

Flame time is the time in seconds that the specimen continues to flame after the burner flame is removed from beneath the specimen. Surface burning that results in a glow but not in a flame is not included.

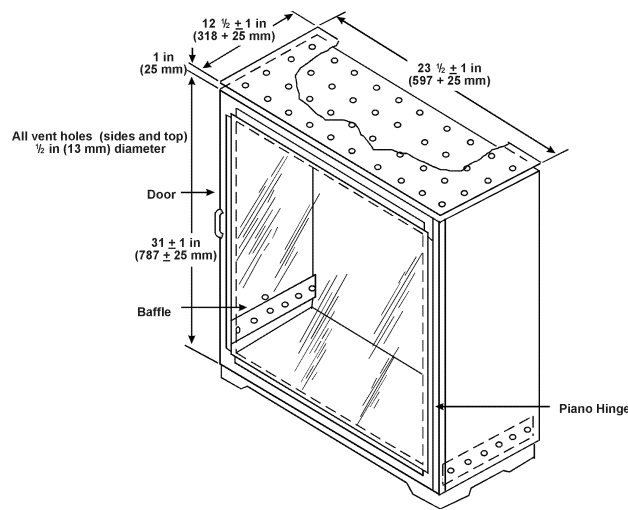
##### 18.2.3 Drip Flame Time

Drip flame time is the time in seconds that any flaming material continues to flame after falling from the specimen to the floor of the chamber. If no material falls from the specimen, the drip flame time is reported to be zero (0) seconds, and the notation "No Drip" is reported. If there is more than one drip, the drip flame time reported is that of the longest flaming drip. If succeeding flaming drips reignite earlier drips that flamed, the drip flame time reported is the total of all flaming drips.

#### 18.3 Test Apparatus

##### 18.3.1 Test Cabinet

The test will be conducted in a draft-free cabinet fabricated in accordance with figures 18-1, 18-2, and 18-3, or other equivalent enclosures acceptable to the FAA. A hole may be drilled into a wall to accommodate the test fixture. It is suggested that the cabinet be located inside an exhaust hood to facilitate clearing the cabinet of smoke after each test. Stainless steel or other corrosion resistant metal 0.04 inch (1 mm) thick will be used for the bottom surface of the chamber.



*Figure 18-1. Sketch of Bunsen Burner Test Cabinet*

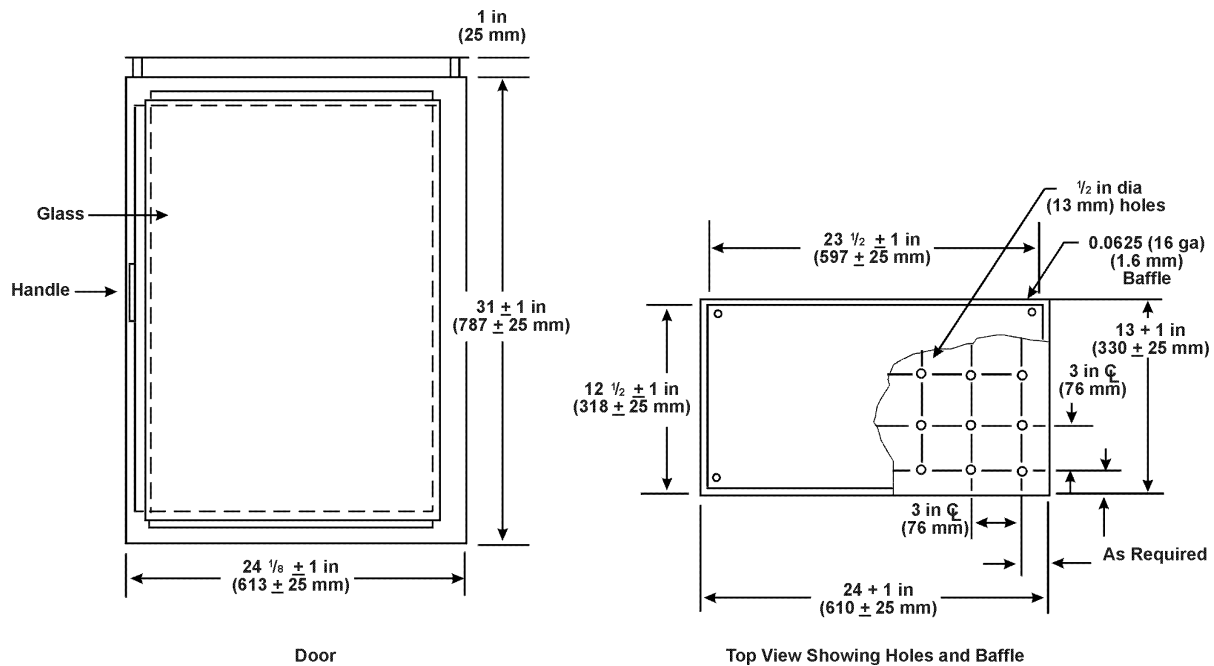


Figure 18-2. Front and Top View of Bunsen Burner Test Cabinet

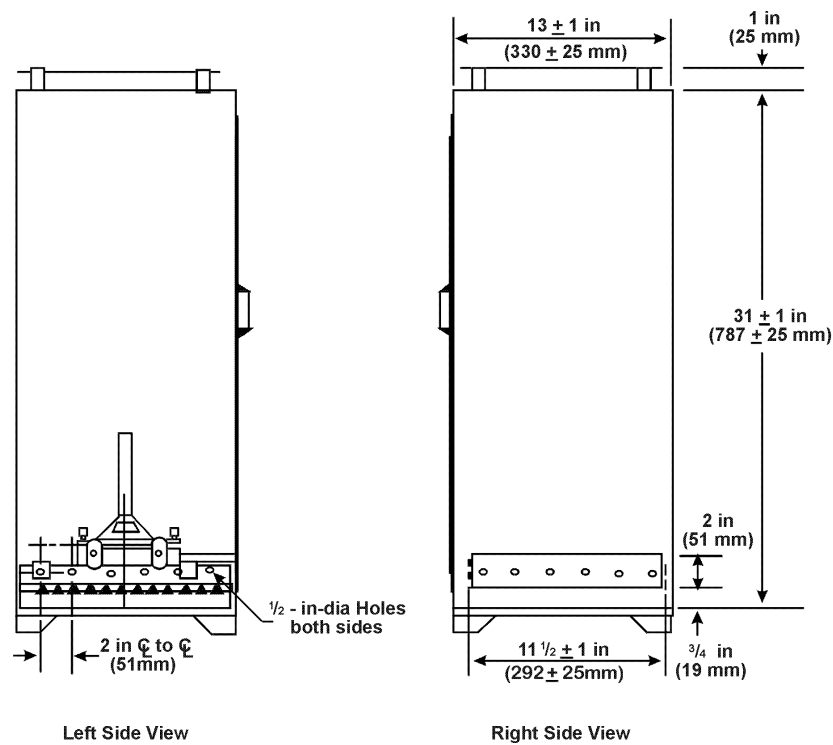


Figure 18-3. Side Views of Bunsen Burner Test Cabinet

### 18.3.2 Specimen Holder

The specimen holder will be fabricated of corrosion-resistant metal, as shown in figure 18-4. This is the same holder used for the 45-degree test specified in FAR 25.855.

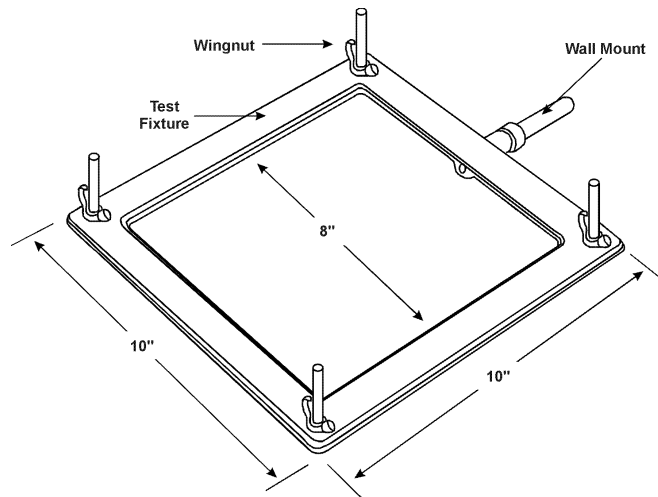


Figure 18-4. Horizontal Test Fixture

### 18.3.3 Burner

The burner shall be a Bunsen or Tirrill type, have a 3/8-inch (10-mm) inside diameter barrel and be equipped with a needle valve located at the bottom of the burner barrel to adjust the gas flow rate and, thereby, adjust the flame height. There should be a means provided to move the burner into and out of test position when the cabinet door is closed.

#### 18.3.3.1 Burner Fuel

Methane gas (99 percent minimum purity) or other burner fuel acceptable to the FAA will be used. Methane is the preferred fuel. It can be used without adding air through the aspirating holes at the bottom of the burner flame barrel, i.e., a pure diffusion flame may be used.

#### 18.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing are essentially as shown in figure 18-5. A control valve system with a delivery rate designed to furnish gas to the burner under pressure of  $2 \frac{1}{2} \pm \frac{1}{4}$  psi ( $17 \pm 2$  kPa) at the burner inlet should be installed between the gas supply and the burner.

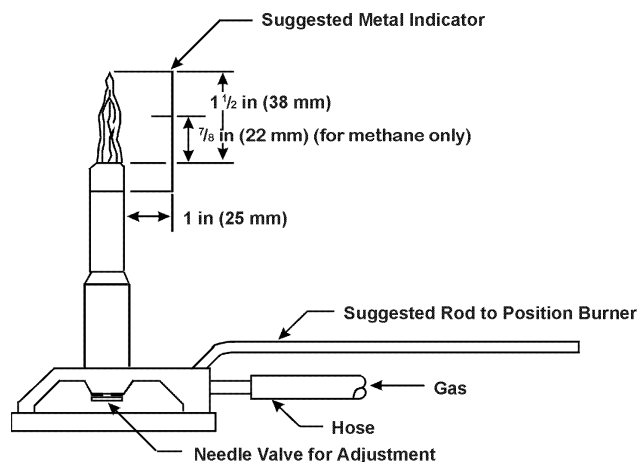


Figure 18-5. Burner Plumbing and Burner Flame Height Indicator

#### 18.3.3.3 Flame Height Indicator

A removable height indicator aids in setting the height of the flame. A suitable indicator has a prong extending 1.5 inches (38 mm) above the top of the burner barrel and spaced 1 inch (25 mm) from the burner barrel, as shown in figure 18-5. If using methane as the burner fuel, it is desirable to have two prongs for measuring the flame height, one prong to indicate the height of the inner cone of the flame, and one prong to indicate the height of the tip of the flame. For methane, it has been determined that when the height of the inner flame is 1.5 inches (38 mm) long the proper flame profile is achieved.

#### 18.3.4 Timer

A stopwatch or other device calibrated to the nearest 0.1 second shall be used to measure the time of application of the burner flame, the flame time, and the drip flame time.

### 18.4 Test Specimens

#### 18.4.1 Specimen Selection

Specimens tested should be cut from new aircraft blankets. If each side of a blanket is composed of a different material, then each side must be tested.

#### 18.4.2 Specimen Number

At least three specimens will be prepared and tested.

#### 18.4.3 Specimen Size

An 8- by 8-inch specimen is the exposed sample size, however, an 11- by 11-inch specimen should be cut in order to pull the specimen taut once secured in the test fixture. The excess material can be trimmed off.

#### 18.4.4 Specimen Thickness

The specimen will be of four-ply configuration. This may be accomplished by folding the blanket in half and then folding it again or by stacking four individual blanket specimens cut to size. This also includes blankets with decorative appliques.

### 18.5 Conditioning

- 18.5.1 Condition specimens at  $70^{\circ} \pm 5^{\circ}\text{F}$  ( $21^{\circ} \pm 3^{\circ}\text{C}$ ) and  $50\% \pm 5\%$  relative humidity for 24 hours minimum. Remove only one specimen at a time from the conditioning environment immediately before testing.

### 18.6 Procedure

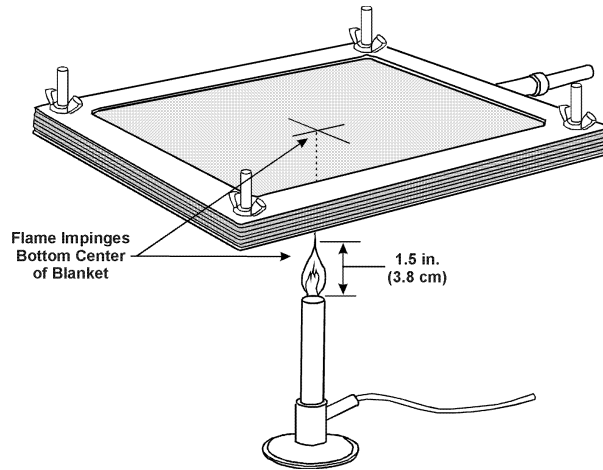
#### 18.6.1 Burner Adjustment

- 18.6.1.1 If using methane as the burner fuel, ensure that the air supply to the burner is shut off.
- 18.6.1.2 Open the stopcock in the gas line fully and light the burner.
- 18.6.1.3 Adjust the needle valve on the burner to give the proper 1.5-inch (38-mm) flame height and remove the flame height indicator.

#### 18.6.2 Test Procedure

- 18.6.2.1 Insert the specimen fixture with specimen in place into the test cabinet. The bottom of the specimen should be 3/4 inch above the level at the top of the burner. When testing two-sided blankets, the “nap” side (the downy or fuzzy surface of the fabric) should be exposed to the flame.

- 18.6.2.2 Close the cabinet door, and keep it closed during the test.
- 18.6.2.3 The timer must be started immediately upon positioning the burner. Position the burner so that it is directly under the geometric center of the test specimen. This is shown in figure 18-6.



*Figure 18-6. Horizontal Test Fixture with Four-Ply Blanket Sample*

- 18.6.2.4 Apply the flame for 12 seconds and then withdraw it by moving the burner at least 3 inches (76 mm) from the specimen or by turning the gas off. If the flame extinguishes during the ignition time for any reason, the test will be rerun.
- 18.6.2.5 If flaming material falls from the test specimen, determine the drip flame time for the specimen.
- 18.6.2.6 Determine the flame time for the specimen.
- 18.6.2.7 After all flaming ceases, the cabinet door should be opened slowly to clear the test cabinet of fumes and smoke. The exhaust fan may be turned on to facilitate clearing the smoke and fumes.
- 18.6.2.8 Remove any material that fell from the specimen to the bottom of the cabinet. If necessary, clean the test cabinet window prior to testing the next specimen.

## 18.7 Report

### 18.7.1 Material Identification

Fully identify the material tested including fiber type and type of FR treatment, if known.

### 18.7.2 Test Results

#### 18.7.2.1 Ignition Time

Report the ignition time.

#### 18.7.2.2 Flame Time

Report the flame time for each specimen tested. Determine and record the average value for flame time.

#### 18.7.2.3 Drip Flame Time

Report the drip flame time for each specimen tested. Determine and record the average value for drip flame time. For specimens that have no drips, record zero (0) for the drip flame time and also record "No Drips."

## 18.8 Requirements

### 18.8.1 Flame Time

The average flame time for all of the specimens tested will not exceed 15 seconds.

### 18.8.2 Drip Flame Time

The average drip extinguishing time for all of the specimens tested will not exceed 5 seconds.

## Chapter 18 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

18.3 Since this test method employs the 45-degree test fixture, the test cabinet called out is the cabinet used for 45-degree testing. Suitable test chambers of the type described are manufactured by U.S. Testing Co., 1415 Park Ave., Hoboken, New Jersey 07030; Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, Illinois 60613; and The Govmark Organization Inc., P.O. Box 807, Bellmore, New York 11710. As stated in the test method, it is permissible to use other draft-free cabinets acceptable to the FAA. One such cabinet is the Horizontal Vertical Flame Chamber manufactured by Atlas Electric Devices (see above for address).

Draft free implies a condition of no air currents in a closed in space. A test cabinet other than one fabricated in accordance with figures 18-1 to 18-3 may be found to be acceptable after review by the FAA. One way of determining whether the cabinet is draft free is to place a smoldering and smoking material, such as a lighted cigarette in the test cabinet, then closing the door and observing the behavior of the smoke for signs of drafts.

The entire inside back wall of the chamber may be painted flat black to facilitate viewing the test specimen.

18.3.2 The specimen holder used is the same holder used for the 45-degree Bunsen burner test with the exception of the mounting stud. Other specimen holders are acceptable provided the test criteria is meet.

18.3.3 A suitable burner is available from Rascher & Betzold Inc., 5410 N. Damen Ave., Chicago, Illinois 60625, Catalog No. R3726A.

If the test cabinet is equipped with a glove box, it is permissible to manually move the burner into test position.

18.3.3.1 A phenomenon that some labs have experienced is a sharp decrease in flame temperature after about three-fourths of the gas originally in the cylinder has been used. This has occurred primarily in labs that have single-stage regulators on their gas cylinders. Single-stage regulators differ from two-stage regulators in that control of the discharge pressure is not as accurate. Few designs should maintain constant or near constant discharge pressures over the full range of cylinder pressures. Therefore, it is necessary to make adjustments periodically to allow for decreasing inlet pressures. Even the slightest drop in pressure can affect the flow rate of gas through the burner orifice. This, in turn, can cause temperature variation. By using a two-stage regulator or adjusting pressure on a single-stage regulator as the cylinder gets low, this problem can essentially be eliminated.

18.3.3.3 The tip of the methane flame is blue, transparent, and difficult to see. It is more easily seen if there is no light on the flame, as in a darkened room. The inner cone of the flame is, however, more visible and easily seen and can be used to monitor flame height. When the flame height (blue transparent tip) is set to 1.5 inches, the height of the inner cone has been found to vary slightly from burner to burner, but is generally about 7/8 inch. Therefore, if the inner cone height is used to monitor flame height, the inner cone height needs to be established for that burner.

18.5 It is recommended that only one specimen be removed at a time from the conditioning chamber prior to subjection to the flame. Some facilities, however, have conditioning chambers located in areas remote from the testing area. In this case, it is permissible to remove more than one specimen at a time if each specimen is covered or carried in a container and protected until the specimen is subjected to the flame.

18.5.1 Industry standard conditioning for textiles is 65 percent relative humidity and 70°F.

18.6.2.2 It is important to note that the test should be watched carefully while it is being conducted. This applies to all samples.

18.6.2.7 The operator should refer to the facility's safety manual for further information dealing with smoke and flammability by-products.

## Chapter 19

### Smoke Test for Insulated Aircraft Wire

#### 19.1 Scope

This test method is used to determine the smoke generating characteristics of insulated aircraft wire using a smoke density chamber.

#### 19.2 Definitions

##### 19.2.1 Specific Optical Density ( $D_s$ )

Specific optical density is a dimensionless measure of the amount of smoke produced per unit area by a material when it is burned. In this test, the maximum value of  $D_s$  that occurs during the first 20 minutes of a test,  $D_m$ , is reported.

#### 19.3 Test Apparatus

##### 19.3.1 Required Equipment

The test chamber and related equipment (e.g., radiant heat furnace, heat flux density gauge, specimen holder, photometric system, straight pilot burner, etc.) will be as defined below:

##### 19.3.1.1 Test Chamber

The test chamber will be a square-cornered box with inside dimensions of  $36 \pm 0.13$  inches ( $914 \pm 3$  mm) wide,  $24 \pm 0.13$  inches ( $610 \pm 3$  mm) deep, and  $36 \pm 0.13$  inches ( $914 \pm 3$  mm) high. A typical test chamber is shown in figure 19-1. The location or size of items such as the chamber door, chamber controls, flowmeters, etc., is optional, except as mandated in the following sections.

19.3.1.1.1 The interior surfaces (except for the chamber door, vents, etc.) will be porcelain-enameled metal or equivalent coated metal that is resistant to chemical attack and corrosion and suitable for periodic cleaning.

19.3.1.1.2 The chamber will be equipped with a door such as that indicated in figure 19-1 to provide convenient access for changing test specimens and for cleaning the chamber walls as required. The door will have a viewing window to observe the chamber interior during a test, especially when any of the flamelets extinguish.

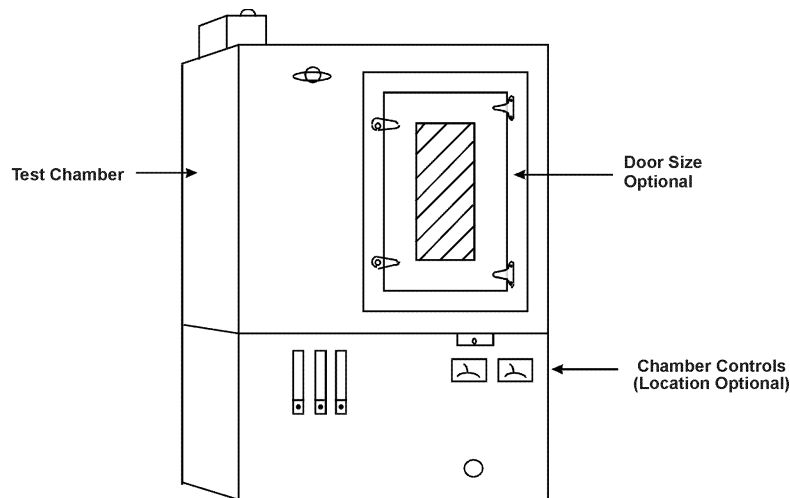


Figure 19-1. Typical Smoke Density Chamber

- 19.3.1.1.3 An inlet-outlet vent for pressure equalization will be provided. The vent and chamber door will have a seal so that when it is closed during tests, there will be no leakage of chamber contents and a small positive pressure can be developed and maintained inside the test chamber.
- 19.3.1.2 Manometer
- A device such as a manometer or pressure transducer will be provided to monitor chamber pressure and leakage. The device will have a range of up to 6 inches (152 mm) of water and be connected to a suitable port in the test chamber.
- 19.3.1.3 Pressure Regulator
- A pressure regulator will be provided that consists of a water-filled bottle vented to a suitable exhaust system and a piece of tubing, not to exceed 10 feet (305 cm) in length, that has an inside diameter of at least 1 inch (25 mm). One end of the tubing will be connected to a port within 6 inches of the top of the chamber; the other end of the tubing will be held in position 4 inches (102 mm) below the water surface.
- 19.3.1.4 Test Chamber Wall Thermocouple
- The temperature of the test chamber wall will be monitored by a thermocouple suitable for measuring a temperature of 35°C. The thermocouple will be mounted with its junction secured to the geometric center of the inner rear wall panel of the chamber using an electrical insulating disk cover.
- 19.3.1.5 Electric Power
- Six hundred fifty watts of 115V, 60 Hz, single phase electric power will be provided for the radiant heat furnace and accessories. Where line voltage fluctuations exceed 2.5 percent, a constant voltage transformer will be provided.
- 19.3.1.6 Radiant Heat Furnace
- An electric furnace and associated controlling devices, such as shown in figures 19-2 and 19-3, will be provided that are capable of providing a constant thermal flux density of  $2.5 \pm 0.05 \text{ W/cm}^2$  ( $2.2 \pm 0.04 \text{ Btu/ft}^2/\text{second}$ ) on the specimen surface.
- 19.3.1.6.1 Furnace Construction
- The dimensions shown in figure 19-2 for the electric furnace are critical. The furnace will be located centrally along the long axis of the chamber with the opening facing toward and approximately 12 inches (305 mm) from the right wall. The centerline of the furnace will be approximately 7.75 inches (197 mm) above the chamber floor.
- 19.3.1.6.2 Heating Element
- The heating element will consist of a coiled wire capable of dissipating about 525 W. With the furnace installed, the heating element will be positioned so that the coil loops are at the 12 o'clock position, as shown in figure 19-3.
- 19.3.1.6.3 Furnace Control System
- The furnace control system will be capable of controlling the radiant heat output at the required level of  $2.5 \pm 0.05 \text{ W/cm}^2$  ( $2.2 \pm 0.04 \text{ Btu/ft}^2/\text{second}$ ), as measured by the heat flux density gauge, under steady-state conditions with the chamber door closed for at least 5 minutes. The control system will consist of an AC solid-state voltage or power controller and a voltmeter or other means for monitoring the electrical input.

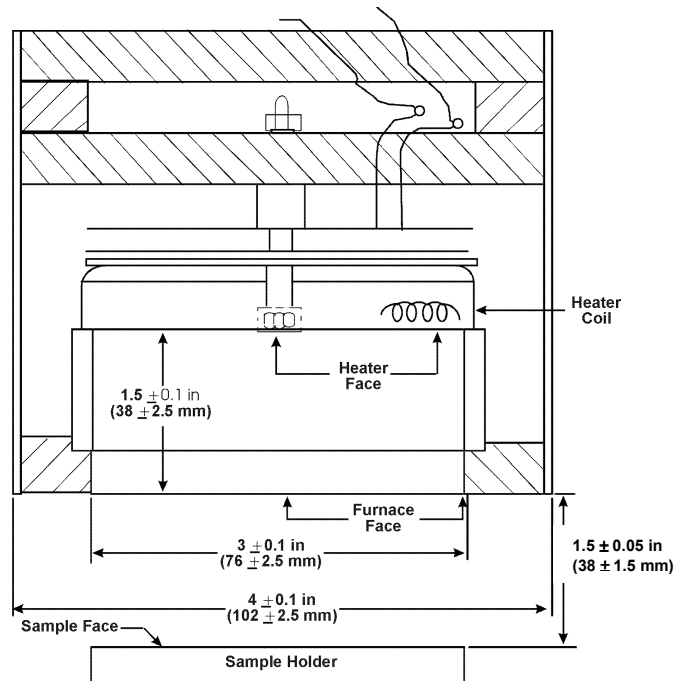


Figure 19-2. Furnace Section

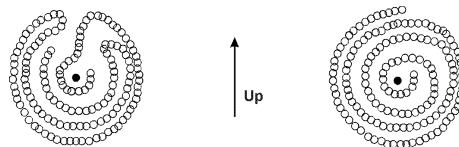


Figure 19-3. Heater Orientation

#### 19.3.1.6.4 Heat Flux Density Gauge

An air-cooled heat flux density gauge will be provided for calibrating the output of the radiant heat furnace. The heat flux density gauge will be a circular foil type, the operation of which has been described by Gardon.

19.3.1.6.4.1 Compressed air at a pressure of 15 to 30 psi (0.1 to 0.21 MPa) will be provided to cool the heat flux density gauge. The body temperature of the heat flux density gauge will be monitored with a thermometer having an accuracy of 2°F (1°C) at 200°F (93°C) in a 0.5- by 0.5- by 1.5-inch (13- by 13- by 38-mm) - long brass or copper well drilled to accept the thermometer with a close fit. Silicone grease will be used to provide good thermal contact. The circular receiving surface of the heat flux density gauge will be spray-coated with an infrared-absorbing black paint. The heat flux density gauge will be calibrated calorimetrically using a procedure that is acceptable to the FAA Administrator.

#### 19.3.1.7 Pilot Burner

The straight burner must be used for flaming tests on insulated wire specimens, as shown in figure 19-4.

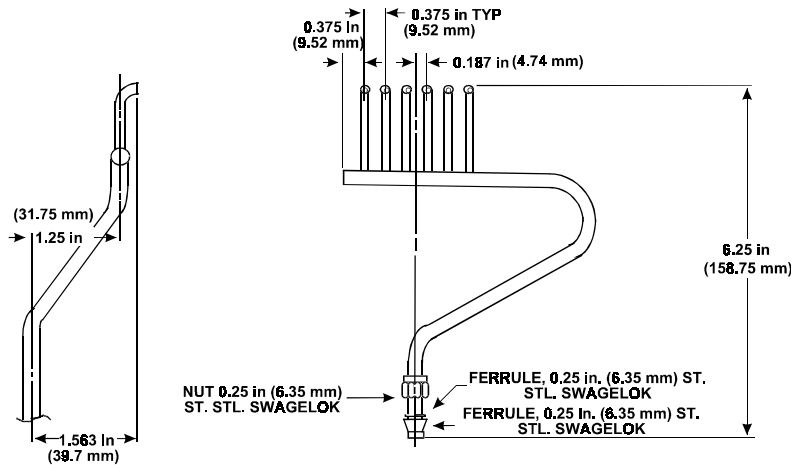


Figure 19-4. Straight Tip Burner

19.3.1.7.1 The six tubes will be fabricated from stainless steel tubing having an outer diameter of 0.125 inch (3.2 mm) and an inner diameter of 0.055 inch (1.4 mm)  $\pm 0.001$  inch (0.025 mm). The six tubes will be attached to a common manifold, as shown in figure 19-5, fabricated from stainless steel tubing having an outer diameter of 0.25 inch (6.4 mm) and a wall thickness of 0.035 inch (0.9 mm). One end of the manifold will be closed, and the other end will be attached to a gas supply fitting on the chamber floor.

19.3.1.7.2 The pilot burner will be centered in front of and parallel to the specimen holder. The tips of the six outer tubes will be placed  $0.25 \pm 0.06$  inch ( $6.4 \pm 1.6$  mm) above the lower opening of the specimen holder and  $0.25 \pm 0.03$  inch ( $6.4 \pm 0.8$  mm) from the face of the specimen surface.

#### 19.3.1.8 Pilot Burner Fuel

The gas fuel for the pilot burner will be prepared by mixing filtered oil-free air with 95 percent minimum purity propane and feeding the mixture to the pilot burner. Each gas will be metered through separate, calibrated flowmeters and needle valves. The air-propane mixture will consist of an air flow rate equivalent to  $0.018 \pm 0.001$  ft<sup>3</sup>/min ( $500 \pm 20$  cm<sup>3</sup>/min) at STP and a propane flow rate equivalent to  $0.0018 \pm 0.0001$  ft<sup>3</sup>/min ( $50 \pm 3$  cm<sup>3</sup>/min) at STP. The compressed air supply will be fed to its flowmeter at  $20 \pm 5$  psi ( $0.14 \pm 0.03$  MPa) and the propane at  $15 \pm 3$  psi ( $0.1 \pm 0.02$  MPa).

19.3.1.8.1 The visible parts of the pilot burner flamelets should be approximately 0.25 inch (6 mm) long with a luminous inner cone approximately 0.13 inch (3 mm) long, as shown in figure 19-6. If the flamelets are not that approximate size, there is probably a difficulty with the air/propane fuel mixture and/or flow rate(s), in which case, the accuracy of the flowmeters should be checked.

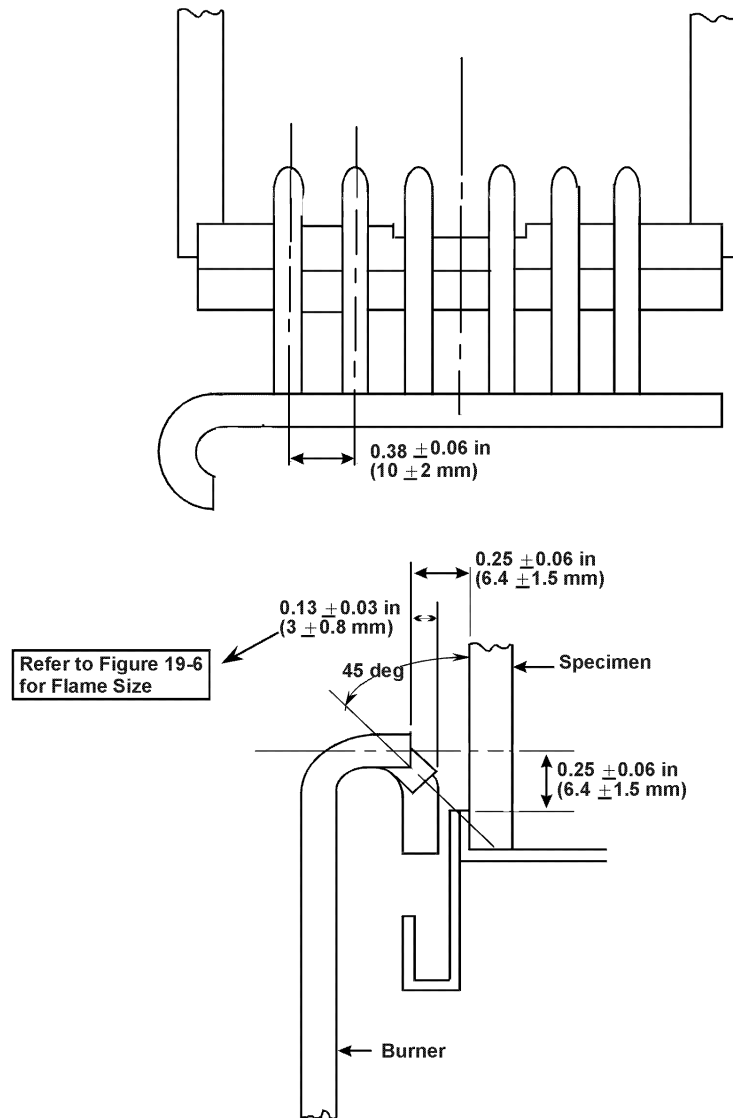


Figure 19-5. Alignment of Holder and Burner

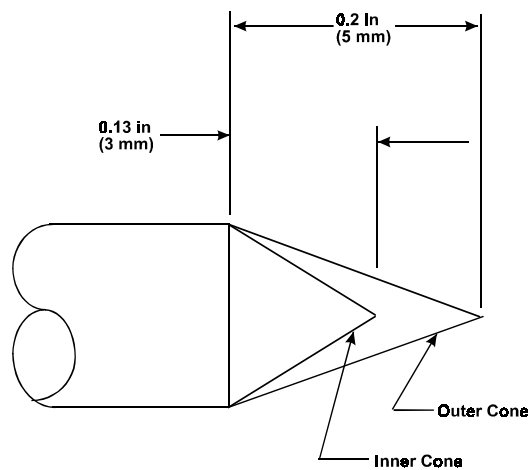


Figure 19-6. Flame Size

### 19.3.1.9 Specimen Holder

The specimen holder will consist of a stainless steel frame, a backing made of insulation millboard, a spring and retaining rod to secure the specimen in place, and aluminum foil for wrapping the specimen.

#### 19.3.1.9.1 Specimen Holder Frame

The specimen holder frame will be fabricated of stainless steel sheet by bending and brazing (or spot welding) stainless steel sheet of  $0.025 \pm 0.002$ -inch ( $0.64 \pm 0.05$ -mm) nominal thickness to conform in shape and dimension to figure 19-7. The frame will be at least 1.5 inches (38 mm) deep and will provide an exposed specimen surface that is nominally 2.56 by 2.56 inches (65 by 65 mm) and that is at least 6.5 inches<sup>2</sup> (4,194 mm<sup>2</sup>) in area.

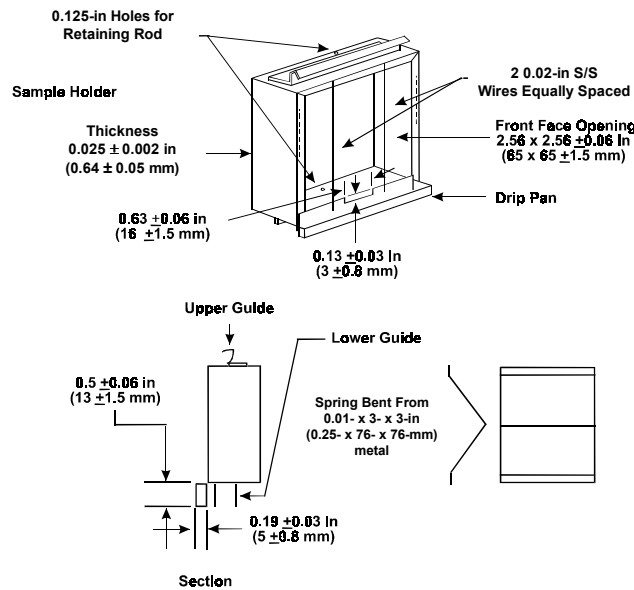


Figure 19-7. Details of Specimen Holder

19.3.1.9.1.1 A drip pan to catch and retain dripping material will be attached to the bottom front of the holder.

19.3.1.9.1.2 Guides to permit accurate alignment of the exposed specimen area in front of the furnace opening will be attached to the top and bottom of the holder frame.

#### 19.3.1.9.2 Specimen Backing

A piece of insulation millboard will be used as a backing for the specimen and as a simulated blank specimen. The millboard will be nominally 0.5 inch (13 mm) thick with a density of  $50 \pm 10$  lb/ft<sup>3</sup> ( $0.8 \pm 0.16$  g/cm<sup>3</sup>) or equivalent. Pieces will be cut  $2.91 \pm 0.03$  by  $2.91 \pm 0.03$  inch ( $74 \pm 1$  by  $74 \pm 1$  mm) to fit inside the specimen holder.

#### 19.3.1.9.3 Retaining Spring

A spring bent from 3- by 2.94- by 0.01-inch (76- by 75- by 0.25-mm) -thick stainless steel sheet will be used with a stainless steel retaining rod to securely hold the specimen and millboard backing in position during testing.

#### 19.3.1.9.4 Aluminum Foil

Smooth aluminum foil that is  $0.0012 \pm 0.0005$  inch ( $0.03 \pm 0.01$  mm) thick will be used to wrap test specimens prior to their insertion in the holder.

#### 19.3.1.10 Support for Radiant Heat Furnace and Specimen Holder

A typical support frame to support the radiant heat furnace and specimen holder is shown in figure 19-8. This support frame will have a provision to establish accurate alignment for the furnace opening so that it is  $1.5 \pm 0.031$  inches ( $38 \pm 1$  mm) away from, parallel to, and centered with the exposed specimen surface. Adjustment screws will be provided to align the furnace with reference to the specimen. The framework will have two 0.38-inch (10-mm) -diameter transverse rods of stainless steel to accept the guides of the specimen holder. The rods will support the holder so that the exposed specimen surface is parallel to the furnace opening. Spacing stops will be mounted at both ends of each rod to permit rapid and accurate lateral positioning of the specimen holder. An externally operated control rod will be provided to replace the test specimen with the blank specimen holder in front of the furnace.

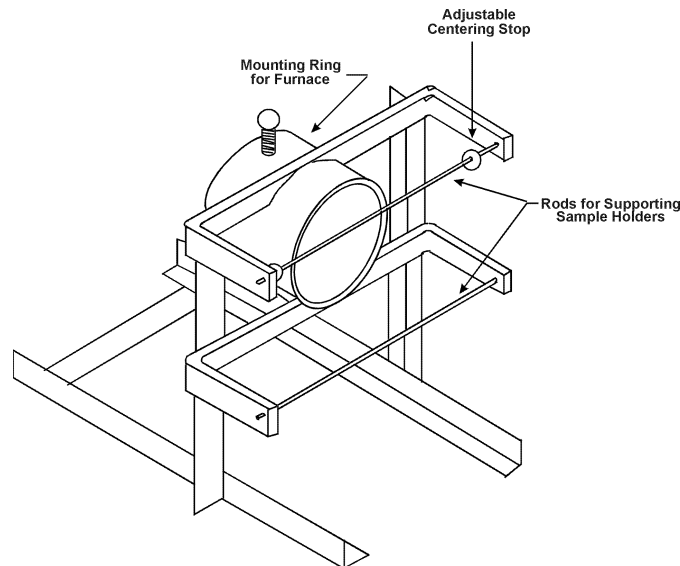


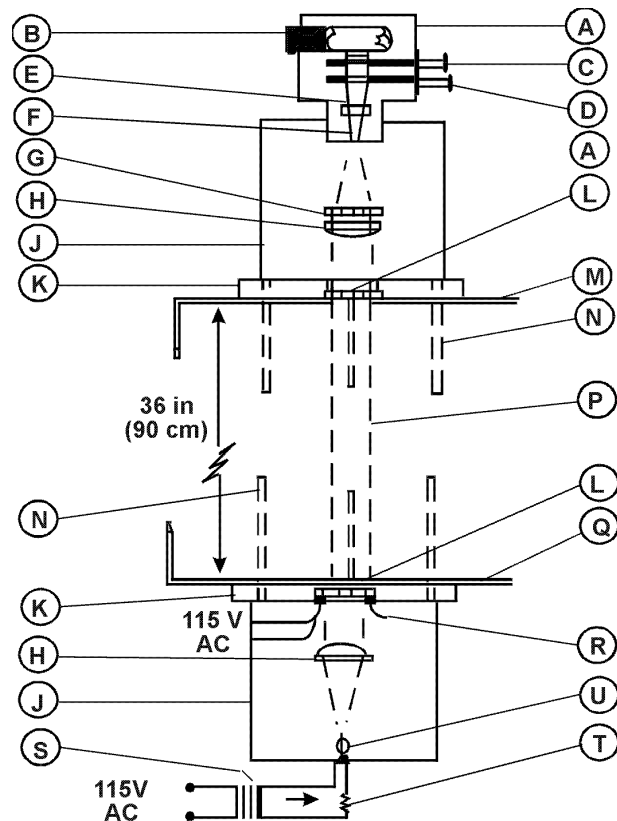
Figure 19-8. Typical Furnace Support

#### 19.3.1.11 Photometric System

A photometric system capable of detecting light transmittance values of 1 percent minimum to an accuracy of 0.03 percent will be provided. The system will consist of a light source and photomultiplier tube that are oriented vertically to reduce measurement variations due optical density, to stratification of the smoke in the chamber during the test, a photomultiplier microphotometer that converts the photomultiplier tube output to relative intensity and/or to and a strip chart recorder or other suitable means to record light transmission versus time. A typical system is shown in figures 19-9 and 19-10.

##### 19.3.1.11.1 Light Source

The light source will be an incandescent lamp mounted in a sealed, light-tight box below the chamber floor and operated at a light brightness temperature of  $2200 \pm 100$ K controlled by a constant-voltage transformer. The box will contain the necessary optics to produce a collimated light beam  $1.5 \pm 0.13$  inches ( $38 \pm 3$  mm) in diameter, passing vertically up through the chamber. The light source and its optics will be isolated from the chamber



- A - Photomultiplier Housing
- B - Photomultiplier Tube and Socket
- C - Upper Shutter Blade with ND2 Filter over One Aperture
- D - Lower Shutter Blade with Single Aperture
- E - Opal Diffuser Filter
- F - Aperture Disk
- G - Neutral Density Compensating (from set of 9)
- H - Lens 7 Diopter (2)
- J - Optical System Housing (2)
- K - Optical System Platform (2)
- L - Optical Windows (2)
- M - Chamber Roof
- N - Alignment Rods (3)
- P - Parallel Light Beam 1.5 in (37.5 mm) Diameter
- Q - Chamber Floor
- R - Optical Window Heater, Silicone-Fiberglass 50W/115V
- S - Regulated Light Source Transformer, 115/125 V-6 V
- T - Adjustable Resistor, Light Source Adjusted for 4V
- U - Light Source

*Figure 19-9. Photometer Detail*

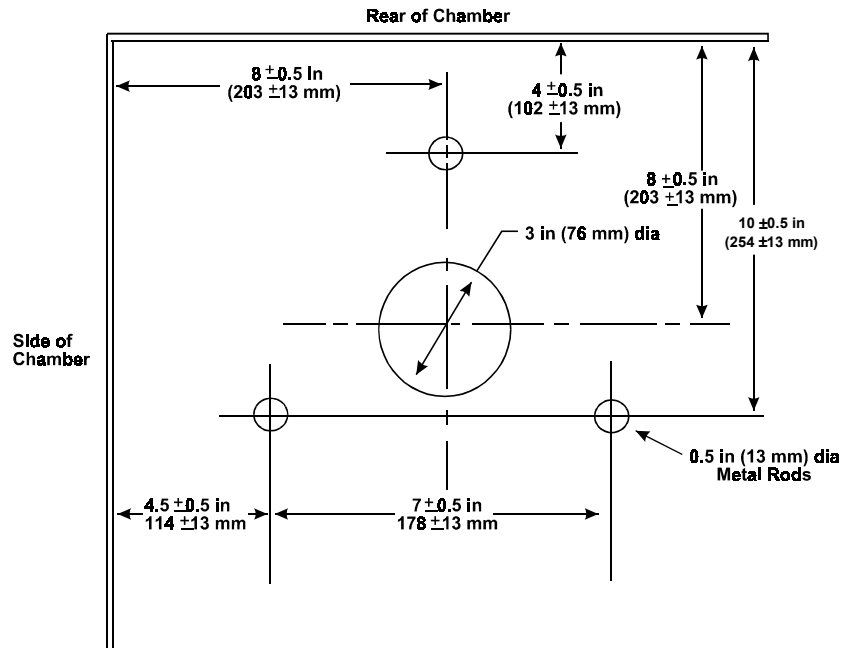


Figure 19-10. Optical System Location Plan View

atmosphere by a glass window that is mounted flush with the chamber bottom panel and sealed to prevent leakage of chamber contents. To minimize smoke condensation, the window will be provided with a ring-type electric heater mounted in the light-tight box, out of the light path, that maintains a minimum window temperature of 125°F (52°C) on the surface of the window inside the chamber.

#### 19.3.1.11.2 Photomultiplier Tube

The photomultiplier tube will have an S-4 linear spectral response and a dark current less than  $10^{-9}$  ampere.

19.3.1.11.2.1 The photomultiplier tube and associated optics will be mounted in a second light-tight box that is located above the chamber ceiling directly opposite the light source. The photomultiplier tube and its optics will be isolated from the chamber atmosphere by a glass window that is mounted flush with the chamber ceiling panel and permits viewing a cross section of  $1.5 \pm 0.13$  inches ( $38 \pm 3$  mm). The window will be sealed to prevent the leakage of chamber contents.

#### 19.3.1.11.3 Microphotometer

The microphotometer will be capable of converting the signal from the photomultiplier tube to relative intensity and/or optical density. The microphotometer/photomultiplier tube combination will be sensitive enough that the microphotometer can be adjusted to produce a full-scale reading (100 percent relative light intensity or optical density = 1) using the photomultiplier tube's response (output) to the light source when a filter of 0.5 or greater optical density is placed in the light path.

#### 19.3.1.11.4 Alignment Fixture

The two optical windows and their housings will be kept in alignment and spaced  $36 \pm 0.125$  inches ( $914 \pm 3$  mm) apart with an alignment fixture consisting of three metal rods, 0.5-0.75 inch (13-19 mm) in diameter fastened securely to 0.31-inch (8-mm) -thick externally mounted top and bottom plates and symmetrically arranged about the collimated light beam.

#### 19.3.1.11.5 Optical Filters

A set of nine neutral color optical filters—0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9 optical density—will also be provided. The optical filters, one or more, as required, may be mounted in the light path in the optical measuring system to compensate for the sensitivity of the photomultiplier tube. These filters can also be used to adjust the photometric system as the light source and/or photomultiplier tube changes sensitivity through aging and/or as discoloration or deterioration of the optical windows occurs.

#### 19.3.1.11.6 Recorder

A recording device will be furnished that provides a record of the percent of light transmission and/or optical density versus time during the test. The record will consist either of a continuous curve on a chart recorder or discrete values taken at least every 5 seconds with a computerized data acquisition system.

#### 19.3.1.12 Exhaust Hood

A method for removing the chamber contents after each test will be provided. A fitting for removing the chamber contents can be connected to a suitable exhaust hood. Locating an exhaust hood directly above the smoke chamber door is recommended as an additional safety device.

#### 19.3.1.13 Conditioning Chamber

A conditioning chamber capable of maintaining test specimens at a temperature of  $70 \pm 5^\circ\text{F}$  ( $21 \pm 3^\circ\text{C}$ ) and  $50\% \pm 5\%$  relative humidity will be provided.

### 19.4 Test Specimen Selection and Preparation

#### 19.4.1 Specimen Number

A minimum of three specimens will be prepared and tested.

#### 19.4.2 Specimen Size

Insulated wire specimens, 16 AWG and smaller, will be wrapped on the frame, as shown in figure 19-11. Insert the end of a 10-foot length of insulated wire through one of the holes in the frame and complete the wrap by inserting the finishing end of the insulated wire through the unused hole and under the last turn to prevent unwinding. Specimens, 14 AWG and larger, should be cut approximately 3 inches in length and laid side by side, covering the entire opening in the front of the specimen holder. This is readily accomplished by first covering the front of the Marinite millboard with aluminum foil and inserting it and the spring into the specimen holder. The pieces of wire are then inserted through the front of the holder and held vertically. This is shown in figure 19-12.

#### 19.4.3 Specimen Orientation

Insulated wire specimens will only be tested in a vertical orientation.



## 19.5 Test Chamber Calibration

### 19.5.1 Furnace Protection

Prepare a blank specimen consisting of 0.5-inch-thick alumina-silica millboard mounted in a specimen holder (see section 6.3.1.9.2). To reduce problems with the stability of the heat flux density from the furnace, maintain the blank specimen in front of the furnace when no testing or calibration is being conducted.

### 19.5.2 Periodic Calibration Procedure

Conduct a periodic calibration of the system as follows.

#### 19.5.2.1 Photometric System

The photometric system used in this test method is an inherently linear device. Check the system for proper photocell alignment. Verify, at least every 2 months, the linearity of the system using a set of neutral optical density filters or equivalent. If erratic behavior is observed or suspected, check the system more frequently.

#### 19.5.2.2 Furnace

Use the approved heat flux density gauge to monitor the heat flux density produced by the furnace. Place the heat flux density gauge on the horizontal rods of the furnace support framework and accurately position it in front of the furnace opening by sliding and displacing the blank specimen holder against the spacing stop (see section 6.3.1.10). With the chamber door closed and the inlet vent opened, adjust the compressed air supply to the heat flux density gauge cooler to maintain its body temperature at  $200 \pm 50^\circ\text{F}$  ( $93 \pm 3^\circ\text{C}$ ). Adjust the setting of the furnace control voltage or power controller to obtain the calibrated millivolt output of the heat flux density gauge corresponding to a steady-state irradiance of  $2.5 \pm 0.05 \text{ W/cm}^2$  ( $2.2 \pm 0.04 \text{ Btu/ft}^2/\text{second}$ ). After the irradiance has reached the required value and has remained steady state for at least 5 minutes, remove the heat flux density gauge from the chamber and replace it with the blank specimen holder.

19.5.2.2.1 Record the setting of the furnace control voltage or power controller and use this setting until a future calibration indicates it should be changed.

#### 19.5.2.3 Chamber Leak Test

Test the smoke density chamber leak rate at least once a month or more often if loss of chamber pressure is suspected, using the following procedure.

19.5.2.3.1 Place the heater switch in the OFF position. Close the inlet vent and the chamber door.

19.5.2.3.2 Pressurize (e.g., by bleeding in a small amount of air through the port used for the heat flux density gauge) the chamber to at least 3 inches of water above ambient as indicated by the manometer.

19.5.2.3.3 Note the chamber pressure. Verify that the chamber pressure leakage rate is less than 2 inches of water in 2 minutes.

#### 19.5.2.4 Total System

Check the total system at least once a month by testing a material that has shown a consistent specimen-to-specimen  $D_m$  value in the range of 1 to 5  $D_m$  and that is and will continue to be readily available. Maintain a record of the test results obtained; if erratic values are observed, identify and correct any instrumental or operational deficiencies.

### 19.5.3 Chamber Cleaning

Clean the optical system windows, viewing window, chamber walls, and specimen holders as follows.

#### 19.5.3.1 Optical System Windows

Clean the exposed surfaces of the glass separating the photo detector and light source housings from the interior of the chamber after each test. Clean the top window first, then the bottom window, using a nonabrasive cloth dampened with a suitable cleaner. Dry the window to prevent streaking or film buildup. Do not use any cleaners that contain wax because wax will cause the smoke to adhere to the glass more quickly.

#### 19.5.3.2 Viewing Window

Clean the viewing window periodically as required to allow viewing of the chamber interior during testing. The same cleaners used in section 6.6.3.1 have been found satisfactory.

#### 19.5.3.3 Chamber Walls

Clean the chamber walls periodically to prevent excessive buildup of smoke products. An ammoniated spray detergent and nonabrasive scouring pad have been found effective.

#### 19.5.3.4 Specimen Holders

Remove any charred residues on the specimen holders and horizontal rods securing the holder position to prevent contamination of subsequent specimens.

## 19.6 Procedure

19.6.1 Each day, prior to testing, adjust the chamber as follows.

19.6.1.1 Calibrate the furnace output according to section 6.6.2.3 to determine the correct furnace voltage.

19.6.1.2 Balance the photomultiplier dark current and set the clear beam reading to 100 percent relative transmission or to optical density 0.00.

19.6.1.3 Set the photomultiplier scale at 100. Shut lower shutter blade (D) directly below photomultiplier tube (B) (see figure 19-9). Set your data recording device to zero.

19.6.2 Conduct the test procedure as follows.

19.6.2.1 Ensure that the specimen(s) have been properly prepared per sections 6.4.1 through 6.4.5.

19.6.2.2 Ensure that the chamber wall temperature is  $95 \pm 4^{\circ}\text{F}$  ( $35 \pm 2^{\circ}\text{C}$ ).

19.6.2.3 Ensure that the furnace voltage has been set correctly.

19.6.2.4 Set the clear beam reading to 100 percent relative transmission or to optical density 0.00 (see section 6.7.1.2).

19.6.2.5 Position the pilot burner in front of and parallel to the specimen holder. Turn on the pilot burner fuel (see section 6.3.1.8) and light the flamelets on the pilot burner. Make sure that all flamelets are ignited and properly adjusted.

19.6.2.6 Open the test chamber door and place the specimen holder on the support. Immediately push the specimen holder into position in front of the furnace, displacing the blank specimen holder to the prepositioned stop, and close the chamber door and inlet vent. For chambers with an external device to move the specimen holder in front of the furnace, place the holder on the support close the door, and then slide the sample into position and simultaneously start the timer and recorder for light transmission.

- 19.6.2.7 Continue the test for a minimum of 20 minutes (1200 seconds).
- 19.6.2.8 Record the percent of light transmission and/or optical density versus time (minutes) during the test.
- 19.6.2.9 Monitor the chamber pressure during the test. If negative pressure (below ambient atmospheric) develops, open the inlet valve slightly to relieve pressure.
- 19.6.2.10 If one or more pilot lights extinguish at the start of the test (first 5 seconds), stop the test, relight the flames, and start the test again. If one or more pilot lights extinguish during the first 10 minutes of the test, the test must be aborted and a new sample of wire run. If one or more pilot lights extinguish after 10 minutes, continue the test, making note of the time of extinguishment and the number of pilot lights extinguished.
- 19.6.2.11 At the termination of the test, remove the test specimen holder from its position in front of the furnace and replace it with the blank specimen holder using the exterior control rod. Begin exhausting the chamber of smoke within 1 minute by opening the door and the inlet vent (and exhaust vent, if used).
- 19.6.2.12 Continue to exhaust the chamber until all smoke has been removed.
- 19.6.2.13 Clean the windows to the housings for the photomultiplier tube and the light source per section 6.6.3.1.
- 19.6.2.14 Record the  $D_s$  for each specimen at the 20-minute point. Calculate and record the maximum specific optical density,  $D_m$ , during the 20-minute (1200-second) test for each specimen according to the formula:

$$D_m = (V / LA) \log_{10}(100 / T_m) \\ = 132 \log_{10}(100 / T_m)$$

where:

$V$  = chamber volume = 18.00 ft<sup>3</sup> (0.510 m<sup>3</sup>)

$L$  = light path length = 3.00 ft (0.914 m)

$A$  = exposed specimen area = 6.57 in<sup>2</sup> (0.00424 m<sup>2</sup>)

$T_m$  = minimum percent light transmission during 20 minutes

$\log_{10}(100/T_m)$  = maximum optical density during 20 minutes

- 19.6.2.15 Calculate and record the average  $D_m$  value and its standard deviation for all the specimens tested for each part/construction. Use the actual  $D_m$  values for this average; do not use the average light transmission value to determine the average  $D_m$  value.

## 19.7 Report

- 19.7.1 Report a complete identification of the part/construction tested such as insulation type, gauge, etc.
- 19.7.2 Report the number of specimens tested (the average  $D_m$ ).
- 19.7.3 Report any additional data or observations, as applicable and/or required by the test plan.

## Chapter 19 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

19.2.1 In this test, the maximum specific optical density ( $^{20}D_s$ ) should be at 20 minutes; however, due to coagulation of smoke particles or to adsorption of smoke particles to the walls of the chamber, it is possible for the maximum to occur earlier in the test.

### 19.3 Recommended Equipment

The following items are recommended, but not required:

Digital Voltmeter—Preferred to monitor furnace voltage and heat flux density gauge output. A Keithley Model 165 Autoranging Multimeter or equivalent has been found acceptable.

Constant Voltage Transformer—A constant voltage transformer is recommended for all installations (see section 19.3.1.5).

Pilot Burner Positioning Fixture—A fixture to accurately position the pilot burner is recommended to establish a precise pilot burner position for testing and to facilitate accurate repositioning of pilot burner after removal and replacement (see figure 19-10).

Automated Igniter System—An automated igniter system is recommended to relight the pilot burner flamelets to ensure that none of them extinguishes for more than 3 seconds during the test. If an electric sparking device is used, an appropriate method of suppression and equipment shielding must be applied to have no interference with ability of data acquisition equipment to accurately record data. Weyerhaeuser Fire Technology Laboratory, Report #9001-in house, describes an automated sparking system. Another system for reignition utilizes a small movable propane flame.

19.3.1.1 Commercially available panels of porcelain-enameled steel (interior surface) permanently laminated to a magnesia—insulation core and backed with galvanized steel (exterior surface)—have been found acceptable.

A thin sheet of transparent material can be placed over optical and viewing windows to protect them against corrosive components in the smoke.

19.3.1.3 Venting the water filled pressure regulator to a suitable exhaust system is necessary to prevent the buildup of unknown contaminants in the laboratory area. The location of the pressure relief tube should be on or within 6 inches of the top of the chamber.

19.3.1.5 A powerstat variable autotransformer, Type 21, from Superior Electric Co., Bristol, Connecticut, or equivalent, has been found satisfactory to transform electric power to that required by the chamber.

A constant voltage transformer from Sola Electric Co., Chicago, Illinois, Catalog Number 23-13-150, or equivalent, has been found satisfactory. A Sorenson Model 200S AC voltage regulator or equivalent has been found satisfactory.

19.3.1.6 Furnace model P/N 6806025700 from Newport Scientific has been found acceptable.

19.3.1.6.3 A Model 470 Series power controller manufactured by Eurotherm, a Model 3AEV1B10C1 Triac manufactured by General Electric Company, or equivalent has been found satisfactory.

The furnace control system should be a reputable unit that provides the parameters to fulfill the requirements of the furnace.

It is recommended to use a digital voltmeter to monitor the furnace voltage output and a digital amperemeter to monitor the furnace current.

19.3.1.6.4 A thermocouple system capable of measuring  $200 \pm 2^\circ\text{F}$  is an acceptable alternate method to monitor the body temperature of the heat flux density gauge. See Gardon, R., "An Instrument for the Direct Measurement of Intense Thermal Radiation," *Review of Scientific Instruments*, Vol. 24, 1953, pp. 360-370.

19.3.1.7 The pilot burner should be aligned with a sample holder and backing board in place. A description of a suitable method of alignment is shown in figure 19-10. Care should be taken to ensure accurate positioning of the pilot tips to the sample holder.

19.3.1.8 Commercially bottled propane has been found acceptable.

19.3.1.9.1 Sample holders must be checked for accuracy with each other; for example, top and bottom mounting devices consistent with each other. It has been noted that misalignment between holders does result in pilot position errors.

19.3.1.9.2 A recommended material is Marinite I.

19.3.1.9.4 Aluminum foil used for household food wrapping is acceptable.

19.3.1.11.2 A thin sheet of transparent material can be placed over optical and viewing windows to protect them from corrosive components in the smoke.

19.4.1 Conditions may require as many as six specimens. Specimens should be marked with an arrow by manufacturers or operator for a consistent direction for test purposes.

19.6.1.3 During recent testing at the FAA William J. Hughes Technical Center, a problem has been discovered with the calculation of  $D_s$  during some NBS chamber testing. The problem is software related. It is possible that during the initial readings taken with a blanked off photcell, there should be some residual voltage reading ( $\pm 1$  millivolt). This is too small a value to be read visually, but can be detected by the computer. The problem is that the current software assumes the initial value is zero and the results are altered accordingly. Because the specific optical density is a logarithmic function, the problem is magnified the higher the value, making the  $D_s$  around the pass/fail point of 200 critical. A  $\pm$  millivolt initial reading can change an actual  $D_s$  of 200 to 175/224, respectively. The fix for this problem is to blank off the photocell prior to each test and let the computer set the "zero."

Computer users could use the following procedure for the computer program: Close the shutter, let the computer read baseline volts (0) ( $mV_b$ ), and determine:

$$\text{Slope} = \frac{100}{(mV_H - mV_b)}$$
$$\%L.T. = (mV - mV_b) * \text{Slope}$$

CAUTION: The door should be opened gradually to avoid exposure to the chamber contents, which may be toxic.

19.6.2.4 This procedure is described in AMINCO NBS Smoke Density Chamber, Catalog No. 4-5800B, Instruction 941B.

19.6.2.13 Ethyl alcohol, methyl ethyl ketone, or equivalent has been found satisfactory.

## Chapter 20

### Dry Arc Tracking Test Procedure

#### 20.1 Purpose

The Dry Arc Tracking Test for wire insulation provides a comparative assessment of insulation degradation and arc propagation of wires in a bundle when subjected to electrical arcing. This test method is for use in obtaining comparative data.

#### 20.2 Test Specimens

Twenty-gauge wires were selected as test standards, since this size is one of the most commonly used gauges in transport category aircraft. At least three tests must be run on each wire insulation material.

##### 20.2.1 Specimen (Preparation)

Cut seven segments of wire, each 14 inches in length. Strip 3/16 inch of insulation from both ends of each wire.

20.2.1.1 Assemble the wires in a 6 around 1 configuration, as shown in figure 20-1.

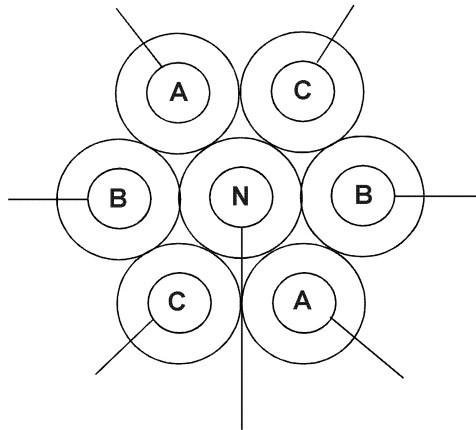


Figure 20-1. Wire Bundle Configuration

20.2.1.2 Arrange the wires straight and parallel. Using a high-temperature lacing tape, mil-tie the wires into a bundle, making a tie 1/4 inch back on the insulation from one set of stripped ends. The other ends are left untied to better facilitate connecting to test leads from a power supply. Make a second tie 2 inches farther back from the first tie. After tying the bundle, apply a small amount of finely powdered conductive graphite to the exposed wire ends (Graphite, 96 percent, 325 Mesh Technical, J.T. Baker, Inc., is acceptable). This can be accomplished by dipping the wire ends directly into a container of the graphite powder. Ensure that the graphite does not get on the wire insulation.

##### 20.2.2 Electrical Connections

Support the bundle horizontally in a laboratory stand using two clamps, approximately 8 inches apart. Position one clamp 1/2 inch from the bundle tie farthest in from the graphite powdered wire ends. The other clamp is used to support the wires toward the end that is connected to the power supply.

20.2.2.1 Connect each of the seven 20-gauge wires to a 7.5-amp aircraft circuit breaker. (This size conforms to standards for circuit breaker protection of bundled 20-gauge airplane wiring.) The 7.5-amp breakers can be mounted in a test box with alligator clips on seven test leads to facilitate connecting to the test wires. Use a three-phase Wye connected power supply

derived from a rotary machine of not less than 5 KVA rating, delivering 215 volts line-to-line at 400 cycles (see figure 20-2).

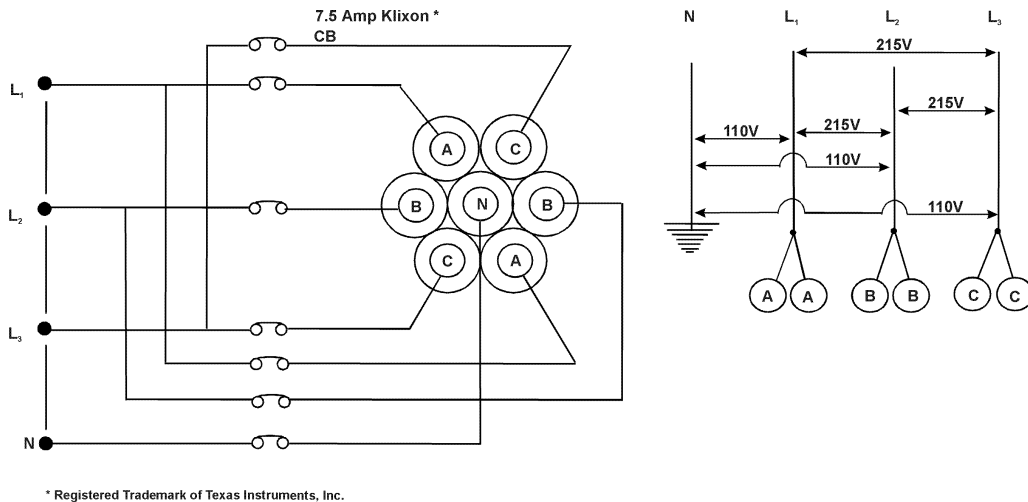


Figure 20-2. Electrical Connections

### 20.2.3 Protective Screen and Test Location

A transparent screen should be used to protect personnel from molten metal and other debris that may be ejected from the specimen during the arc test. Use eye protection for visual observation of the arc. Conduct the test in a ventilated, draft-free location to remove any potentially toxic fumes. Perform testing at room temperature.

## 20.3 Procedure

Initiate the test arc by closing a power contactor. Then, leaving the contactor closed, visually examine, but do not touch, the wires in the bundle after the initial arc. Following that, reset each tripped circuit breaker one time only.

## 20.4 Report

Report the following for each test:

1. A description of the wire tested
2. The power, frequency, and voltage of the three-phase power supply
3. Any damage to the wire bundle after the initial arc
4. The number of open circuit breakers after the initial arc
5. A description of damage to the insulation of each wire in the bundle, including the length of insulation damage, tube effects, welds, etc., after resetting the circuit breakers

## Chapter 21

### Dry Arc-Propagation Resistance

#### 21.1 Purpose

The Dry Arc-Propagation Resistance Test for wire insulation provides an assessment of the ability of an insulation to prevent damage in an electrical arc environment. In service, electrical arcs may originate from a variety of factors, including insulation deterioration, faulty installation, and chafing. It has been documented that results of an arc-propagation test may vary slightly due to the method of arc initiation. Therefore, a standard test method must be selected to evaluate the general arc-propagation resistance characteristics of an insulation. This test method initiates an arc with a vibrating blade. The arc-propagation resistance is defined by the length of arc-propagation damage along the wires in contact with the blade and by the extent of damage to all adjacent wires undamaged by the vibrating blade. The test also evaluates the ability of the insulation to prevent further arc-propagation when the electrical arc is re-energized. The power supply, test current, circuit resistances, and other variables are optimized for testing 20-gauge wires. The use of other wire sizes may require modification of test variables.

#### 21.2 Test Equipment

The following equipment shall be used.

- 21.2.1 An abrader blade made from 6061-T6 aluminum material. Use a 60-grit size grinding wheel or a 60-grit sanding belt to sharpen the blade. A typical abrader blade is shown in figure 21-1. Use the blade sharpening fixture shown in figure 21-2.

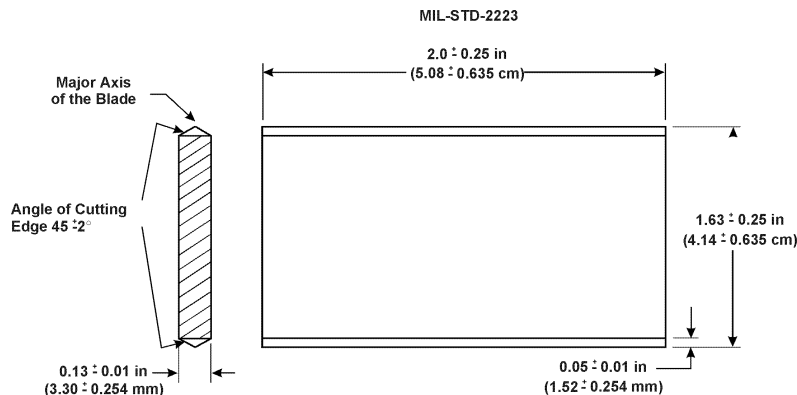


Figure 21-1. Typical Abrader Blade

- 21.2.2 A transparent screen to protect laboratory personnel from molten metals, UV radiation, and other debris that may be ejected from the test specimen.
- 21.2.3 An oscillating mechanism to which the abrader blade is connected. The oscillating mechanism will provide a stroke of 3.81 cm (1.5 inches) at a frequency of  $0.5 \pm 0.05$  cycles per second.
- 21.2.4 A test fixture that includes a test block to hold the wire at right angles to the abrading blade. The block is made from 6061-T6 aluminum.
- 21.2.5 A three-phase Wye connected power supply, grounded at Wye, derived from a rotary machine or solid-state power supply of not less than 20 KVA rating, delivering 208 volts line-to-line at 400 Hz.
- 21.2.6 A mechanical stop constructed of stainless steel.
- 21.2.7 MS3320-7.5 (7.5 amp) and MS25244-50 (50 amp) protective circuit breakers.
- 21.2.8 Variable load and fixed load resistors.

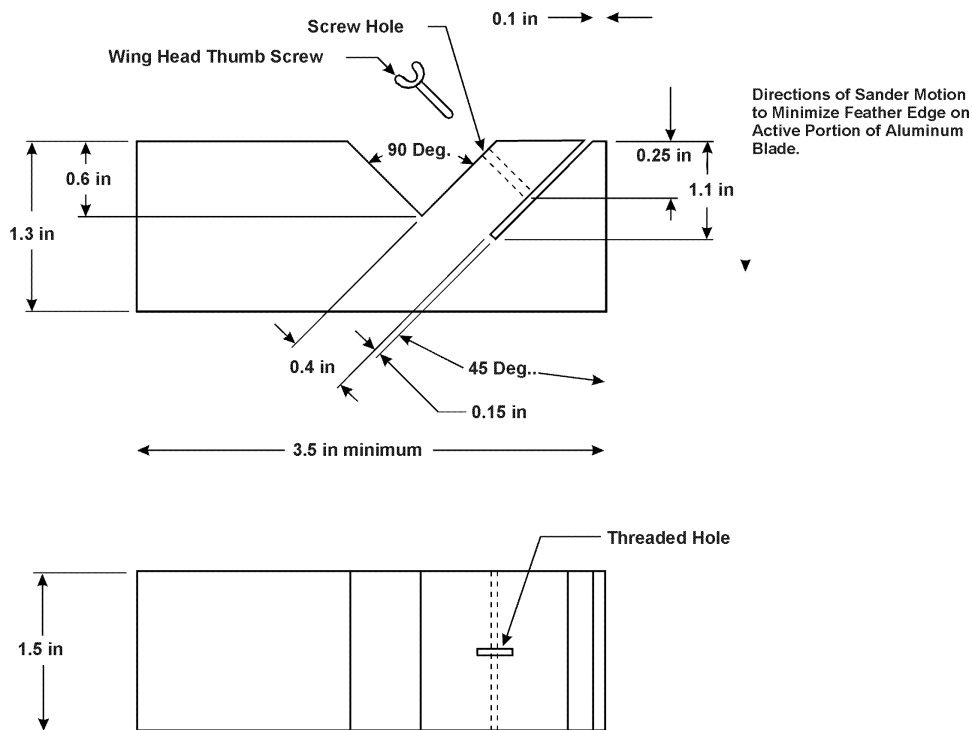


Figure 21-2. Aluminum Blade Sharpening Fixture

21.2.9 MIL-T-43435 (Type V) lacing tape.

21.2.10 MS25231 plastic clamps.

### 21.3 Test Samples

A test sample will consist of 15 bundles of wire. Each bundle is composed of seven wires and will be of sufficient length, 35.6 cm (14 inches) minimum, to allow the bundle to be installed in the test fixture. A minimum of 37.3 meters (122.5 feet) of wire is required. It is recommended that 20-gauge wire be used for the test.

### 21.4 Procedure

#### 21.4.1 Preparation of Bundles

Conduct a 2500 volt Wet Dielectric test on 100 percent of the wire in accordance with the Wet Dielectric test procedure described in MIL-STD-2223, method 3005, before the arc-propagation resistance test is performed. Discard any failed sections of wire. Cut seven wire segments at least 35.6 cm (14 inches) in length for each of the 15 bundles. Clean the cut wires using a cloth saturated with Isopropyl alcohol. Strip both ends of five of the seven-wire segments. Use these stripped ends for making electrical connections. These five-wire segments will be called “active wires.” Form the bundle by laying the seven segments straight and geometrically parallel. Assemble the wires to form the six-around-one configuration shown in figure 21-3. Use MIL-T-43435 lacing tapes to hold the test bundle together. Clean the assembled bundle using a cloth saturated with Isopropyl alcohol prior to installation in the test fixture.

#### 21.4.2 Bundle Installation

A test fixture will be used to hold the wire bundle in place perpendicular to the abrader blade. Details of a suggested test fixture are shown in figure 21-4. Before installation, the wire bundle will be tied with MIL-T-43435 lacing tape at 0.635 cm (0.25 inch) on each side of where the abrader

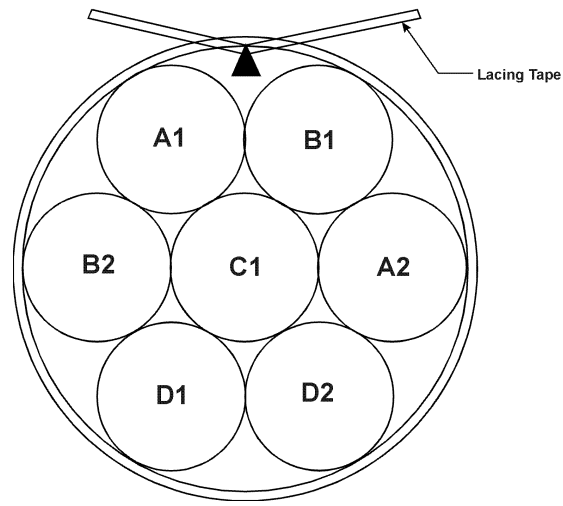


Figure 21-3. Bundle Configuration

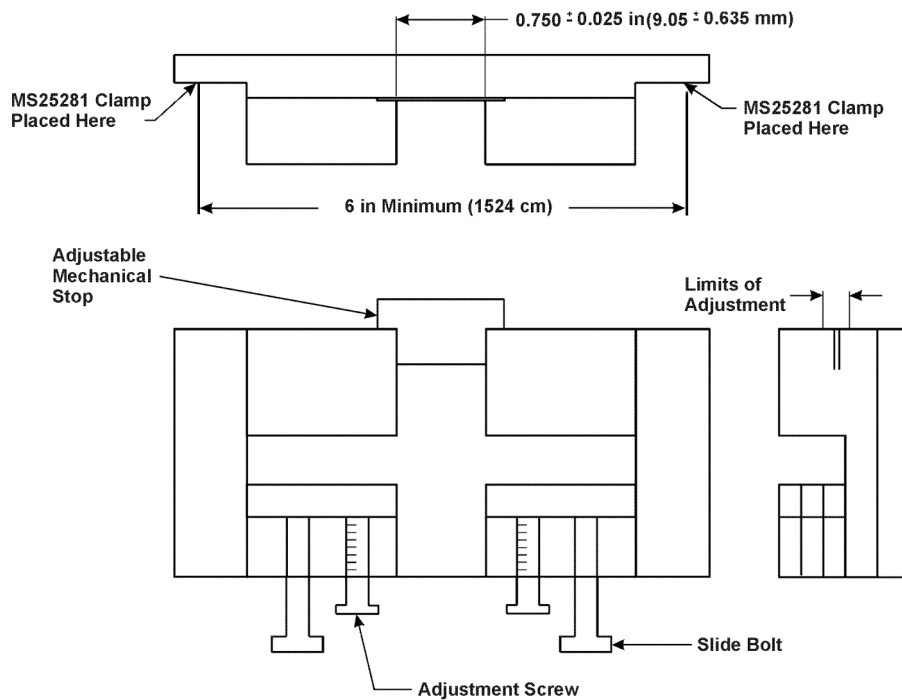


Figure 21-4. Test Fixture

blade is to be applied; then secured to the test fixture. The wire bundle is clamped with MS25281 plastic clamps at two points on the fixture at a minimum distance of 15.24 cm (6 inches). The clamp points are equidistant from the point of application of the abrader. The slide bolt allows the adjusting screw to move the holding plates snugly against the bundle. Ensure that the active wires A1 and B1 are parallel with the top plane of the test fixture and that the passive wires D1 and D2 are in complete contact with the base of the test fixture. The bundle must not be allowed to move while

the abrader blade is cutting wires A1 and B1. The test fixture will contain an adjustable mechanical stop, which may be set to allow for various penetration depths of the vibrating blade.

### 21.4.3 Electrical Connection

Connect the test bundle to the power supply and circuit resistance using the schematic circuit shown in figure 21-5. Connect one end of each active wire to the appropriate phase of the power supply, as shown in table 21-1. Use an MS3320-7.5 (7.5 amp) circuit breaker and a circuit resistance in series with each of the active wires. Use the circuit resistance values shown in table 21-2. Connect the other end of the five active wires under test to variable resistance loads. Adjust the resistance to limit the current flowing through each wire to  $1 \pm 0.2$  ampere. Protect the test circuits with MS25244-50 (50 amp) circuit breakers connected on the supply side of the test setup. Connect the abrader blade to the neutral of the generator. Connect the generator neutral to ground.

MIL-STD-2223

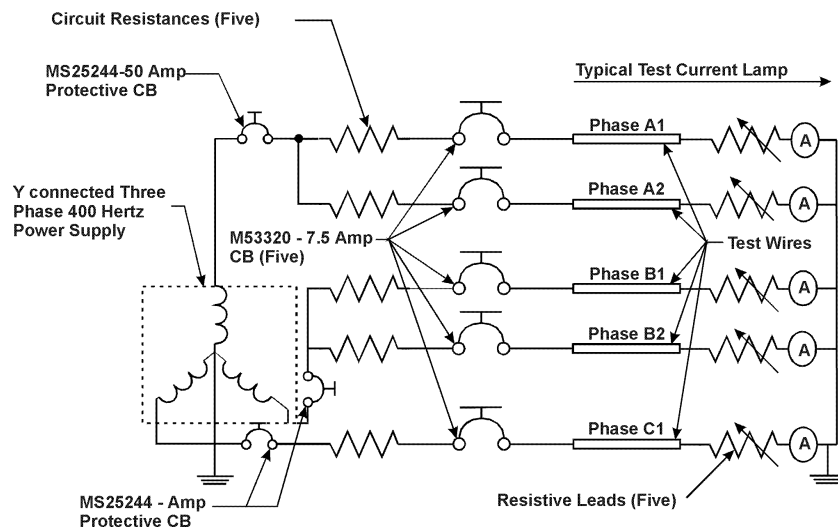


Figure 21-5. Electrical Connection

Table 21-1. Electrical Connection

Wire Identification	Power Supply	Layer
A1	Phase A	Top
B1	Phase B	Top
C1	Phase C	Middle
A2	Phase A	Middle
B2	Phase B	Middle
D1	None	Lowest
D2	None	Lowest

Table 21-2. Circuit Resistance

Test Number	Circuit Resistance (ohm)
1	0.0
2	0.5
3	1.0
4	1.5
5	2.0

#### 21.4.4 Initiation of Test

Test three bundles for each of the five circuit resistances. Install the oscillating mechanism, which may use a reciprocating arm or vertical and horizontal precision linear ball-slides (a suggested ball-slide apparatus is shown in figure 21-6). Adjust the mechanical stop to ensure that the abrader blade penetrates into the A1 and B1 wires a distance of 0.87 times the radius of the seven wire bundles. Close all circuit breakers. Apply a nominal load of 250 grams (0.551 pounds) to the abrader at the point of contact with one wire. Adjust the blade to ensure that the major plane of the blade lies perpendicular to the longitudinal axis of the bundle. Apply the abrader blade on the test bundle. Position the protective screen to shield the operator from ejecting objects and UV radiation. Apply three-phase, 400 Hz power. Actuate the abrader. Allow the abrader blade movement to continue.

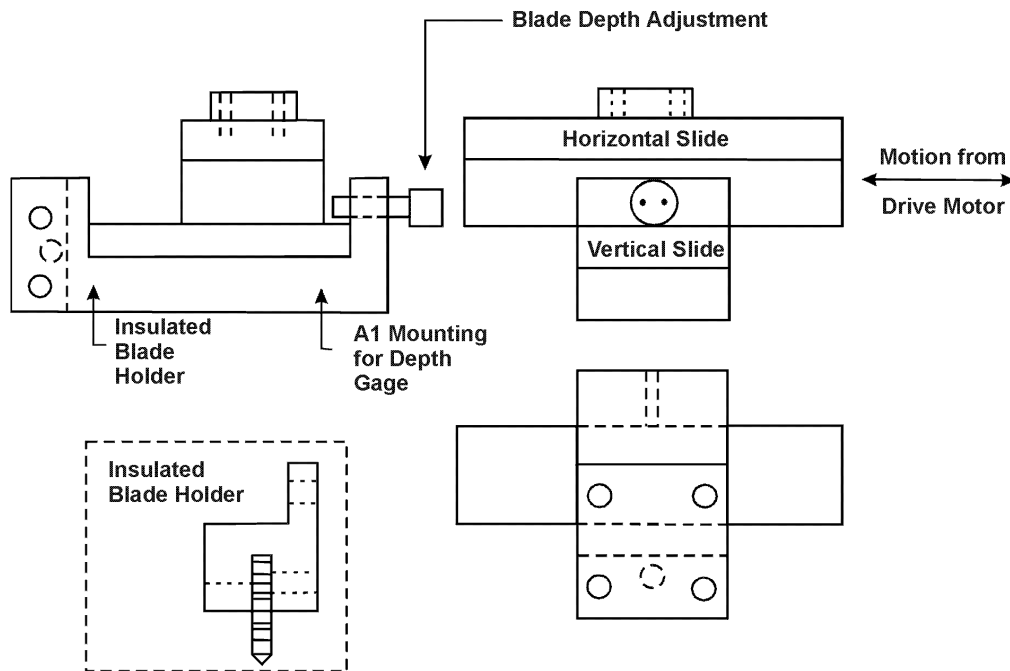


Figure 21-6. Ball-Slide Blade Fixture

### 21.5 Results

Use one of the following conditions to conduct and complete the test.

- 21.5.1 If the abrader cuts through A1 and B1 wires without tripping phase A1 or phase B1 circuit breakers, stop the abrader movement. Disconnect the power.
- 21.5.2 Conduct the 1000 volt Wet Dielectric test on wires A2, B2, C1, D1, and D2 in accordance with the Wet Dielectric procedure of MIL-STD 2223, method 3005. Record the number of wires that fail. Measure and record the total length of physical damage to each wire (including phase A1 and B1 wires) in inches.
- 21.5.3 If a circuit breaker in any of the phases A2, B2, or C1 trips at any time during the test, stop the abrader and disconnect the power. Perform tests as listed in 21.5.2.
- 21.5.4 If either phase A1 or phase B1 circuit breaker trips at any time during the test, stop the abrader. Disconnect the power and determine if the conductor wires A1 or B1 are open. If both wires are open, conclude the test by performing tests as listed in 21.5.2. If wire A1 or wire B1 are not open, wait 3 to 4 minutes, reset the circuit breaker, restart the abrader, and then immediately reapply the power. Continue the test until either phase A1 or phase B1 circuit breaker has tripped a second time,

phases A1 and B1 are open, or the blade movement is stopped by the mechanical stop. CAUTION: DO NOT RESET A CIRCUIT BREAKER THAT TRIPS TWICE. Perform the tests as listed in 21.5.2. Use a new abrader blade edge for each test bundle if any damage is present or if circuit breakers A1 or B1 trip during the test.

- 21.5.5 Circuit breakers should be periodically tested to ensure they still meet the overload requirements of the applicable military specification sheet. Circuit breakers outside their overload trip requirements should be replaced.

## **21.6 Information Required in the Individual Specification**

Specifications will list the minimum number of wires that must pass the dielectric test after the bundle has been energized and, also, the maximum allowable length of physical damage to the individual wires in the bundle.

## **Chapter 22**

### **Cotton Swab Test for Thermal Acoustic Insulation Blankets**

#### **22.1 Scope**

This nonregulatory, industry screening test is intended for use in determining the resistance of thermal acoustic insulation films to flame propagation when tested with alcohol dipped cotton swabs.

#### **22.2 Definitions**

##### **22.2.1 Burn Length**

Burn length is the distance from the original specimen edge to the farthest evidence of damage to the test specimen due to that area's combustion, including areas of partial consumption, charring, or embrittlement but not including areas sooted, stained, warped, or discolored nor areas where material has shrunk or melted away from the heat source.

#### **22.3 Test Apparatus**

##### **22.3.1 Test Area**

Tests will be conducted in a draft-free enclosure. It is suggested that the enclosure be located inside an exhaust hood to facilitate clearing the enclosure of smoke after each test.

##### **22.3.2 Fuel**

Isopropyl alcohol will be used as the flammable solvent.

##### **22.3.3 Ruler**

A ruler or scale graduated to the nearest 0.1 inch (2.5 mm) will be provided to measure the burn length.

##### **22.3.4 Cotton Swabs**

Two cotton tipped applicators (equivalent to Q-tips single-tipped applicators) will be used as the ignition source vehicle. The wooden sticks must be removed before placement on the test samples.

#### **22.4 Test Specimens**

##### **22.4.1 Specimen Size**

The specimen will be a rectangle at least 16 by 24 inches (406.4 by 609.6 mm).

##### **22.4.2 Specimen Fabrication**

Fabricate a test blanket using insulation batting intended for use in the aircraft and the candidate film cover material. The test blanket must be sealed around the perimeter. This may be accomplished by heat sealing, sewing, or using flame-resistant approved tape.

##### **22.4.3 Make sure that the test blanket is vented. This can be accomplished by puncturing the blanket with a small object such as a pin.**

##### **22.4.4 Specimen Number**

One specimen will be prepared and tested.

##### **22.4.5 Specimen Thickness**

The specimen thickness will be the same as the part qualified for use in the airplane.

## 22.5 Test Procedure

- 22.5.1 Prop the test blanket against a nonflammable surface in the position shown in figure 22-1. Make sure that the orientation is correct.

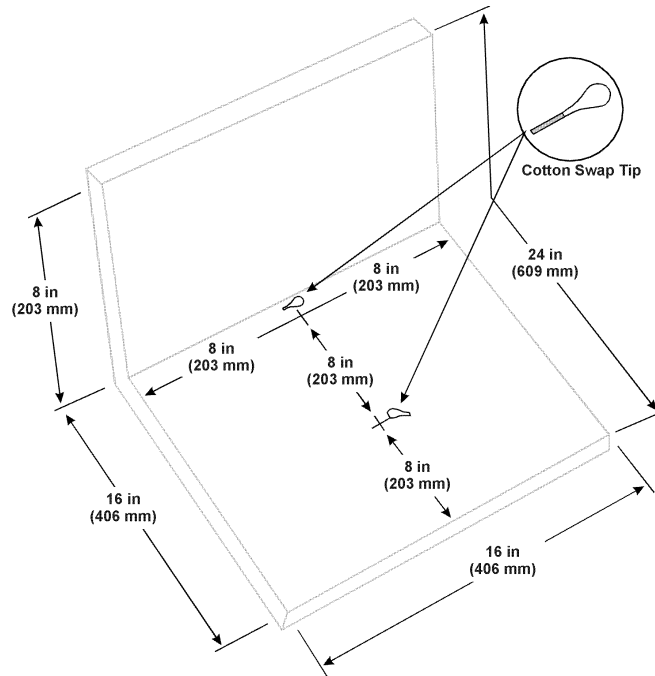


Figure 22-1. Cotton Swab Test Configuration

- 22.5.2 Remove the wooden sticks from the cotton swabs.
- 22.5.3 Dip the cotton-tipped ends into the alcohol. Tweezers can be used to accomplish this.
- 22.5.4 Ignite the cotton-tipped ends and place one flaming tip in the center of the blanket and one in the crease.
- 22.5.5 Allow the cotton-tipped ends to burn to completion or until they self-extinguish.
- 22.5.6 Measure the longest burn lengths extending from the center cotton tip and the crease cotton tip.

## 22.6 Report

- 22.6.1 Identify and describe the test specimen.
- 22.6.2 Report each burn length.
- 22.6.3 Report any flame spread, if applicable.

## 22.7 Requirements

- 22.7.1 No burn length shall exceed 8 inches (203.2 mm).